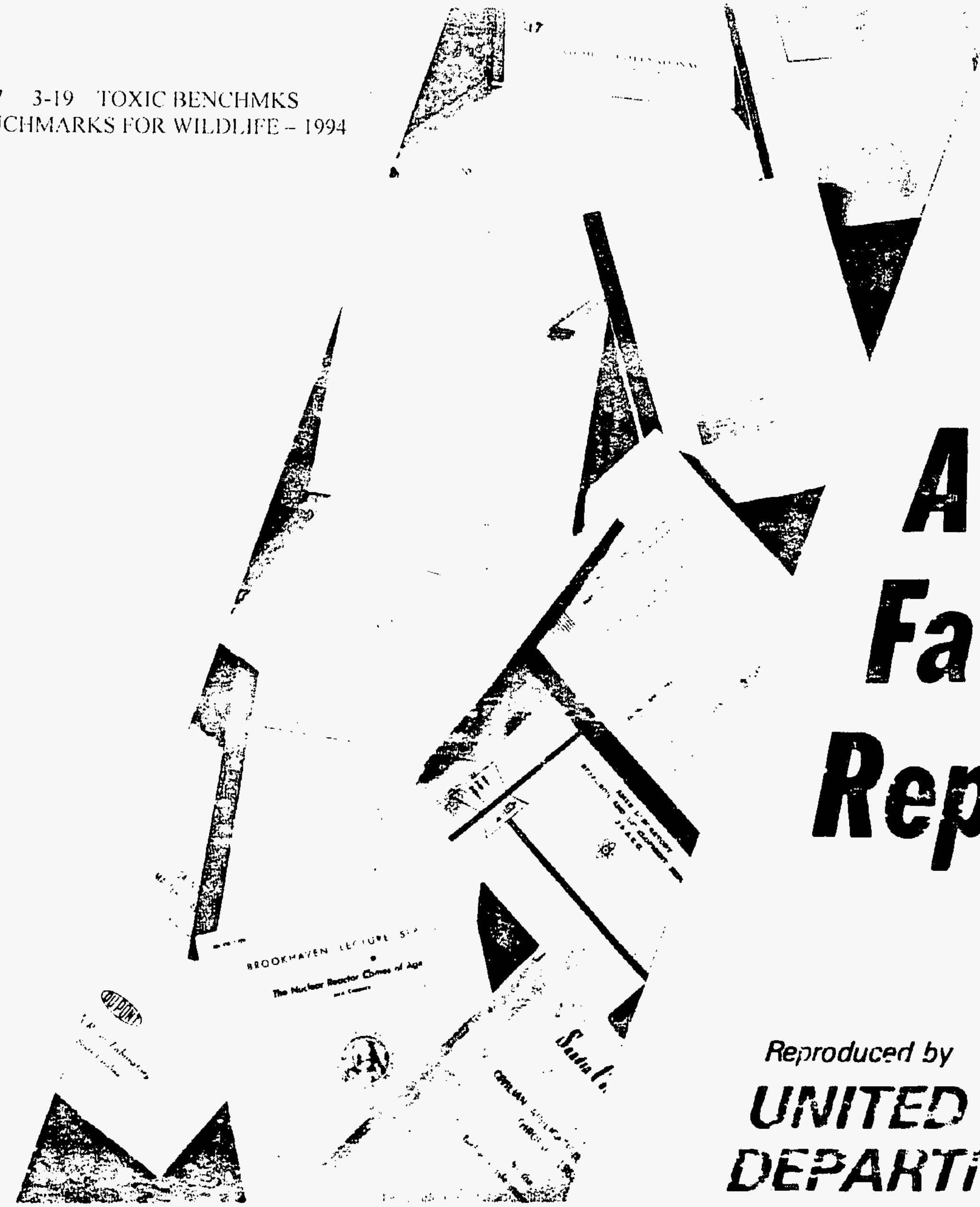

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Toxicological Benchmarks for Wildlife: 1994 Revision

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TABLES

ACRONYMS and ABBREVIATIONS

BAF	Bioaccumulation Factor
BCF	Bioconcentration Factor
bw	Body Weight
COPC	Contaminant of Potential Concern
DOE	United States Department of Energy
EPA	United States Environmental Protection Agency
FCM	Food Chain Multiplier
FEL	Frank Effects Level
HQ	Hazard Quotient
LD_{50}	Lethal Dose to 50 percent of the population
LC_{50}	Lethal Concentration to 50 percent of the population
LOAEL	Lowest Observed Adverse Effects Level
NOAEL	No Observed Adverse Effects Level
P_{oct}	Octanol/Water Partition Coefficient
PCB	Polychlorinated Biphenyl
RfD	Reference Dose
RTECS	Registry of Toxic Effects of Chemical Substances
TCDD	Tetrachlorodibenzodioxin
TCDF	Tetrachlorodibenzofuran
TWA	Time Weighted Average

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EXECUTIVE SUMMARY

The process by which ecological risks of environmental contaminants are evaluated is two-tiered. The first tier is a screening assessment where concentrations of contaminants in the environment are compared to toxicological benchmarks which represent concentrations of chemicals in environmental media (water, sediment, soil, food, etc.) that are presumed to be nonhazardous to the surrounding biota. The second tier is a baseline ecological risk assessment where toxicological benchmarks are one of several lines of evidence used to support or refute the presence of ecological effects.

The report presents toxicological benchmarks for assessment of effects of 76 chemicals on 8 representative mammalian wildlife species and 31 chemicals on 9 avian wildlife species. The chemicals are some of those that occur at United States Department of Energy waste sites; the wildlife species were chosen because they are widely distributed and provide a representative range of body sizes and diets. Further descriptions of the chosen wildlife species and chemicals are provided in the report. The benchmarks presented in this report represent values believed to be nonhazardous for the listed wildlife species. These benchmarks only consider contaminant exposure through oral ingestion of contaminated media; exposure through inhalation or direct dermal exposure are not considered in this report.

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1. INTRODUCTION

The process by which the ecological risks of environmental contaminants is evaluated is two-tiered. In the first tier, a screening assessment is performed where concentrations of contaminants in the environment are compared to toxicological benchmarks. These benchmarks represent concentrations of chemicals in environmental media (water, sediment, soil, food, etc.) that are presumed to be nonhazardous to the biota. While exceedance of these benchmarks does not indicate any particular level or type of risk, concentrations below the benchmarks should not result in significant effects. In practice, when contaminant concentrations in food or water resources are less than these toxicological benchmarks, these contaminants may be excluded from further consideration. If, however, the concentration of a contaminant exceeds a benchmark, that contaminant should be retained as a contaminant of potential concern (COPC) and be subject to further investigation.

Toxicological benchmarks may also be used as part of a weight-of-evidence approach (Suter, 1993) in a baseline ecological risk assessment, the second tier in ecological risk assessment. Under this approach, toxicological benchmarks are one of several lines of evidence used to support or refute the presence of ecological effects. Other sources of evidence include media toxicity tests, surveys of biota (abundance and diversity), measures of contaminant body burdens, and biomarkers.

This report presents toxicological benchmarks for assessment of effects of 76 chemicals on 8 representative mammalian wildlife species (short-tailed shrew, little brown bat, meadow vole, white-footed mouse, cottontail rabbit, mink, red fox, and whitetail deer) and 31 chemicals on 9 avian wildlife species (American robin, American woodcock, wild turkey, belted kingfisher, great blue heron, barred owl, barn owl, Cooper's hawk, and red-tailed hawk) (scientific names are presented in Appendix B). These species were chosen because they are widely distributed and provide a representative range of body sizes and diets. The chemicals are some of those that occur at United States Department of Energy (DOE) waste sites. The benchmarks presented in this report represent values believed to be nonhazardous for the listed wildlife species. These benchmarks only consider contaminant exposure through oral ingestion of contaminated media. Exposure through inhalation or direct dermal exposure are not considered in this report.

2. AVAILABILITY AND LIMITATIONS OF TOXICITY DATA

Information on the toxicity of environmental contaminants to terrestrial wildlife can be obtained from several sources including the United States Environmental Protection Agency (EPA) Terrestrial Toxicity Data Base (TERRE-TOX, see Meyers and Schiller, 1986); U. S. Fish and Wildlife Service reports, EPA assessment and criteria documents, and Public Health Service toxicity profiles. In addition, many referred journals (e.g., Environmental Toxicology and Chemistry, Archives of Environmental Contamination and Toxicology, Journal of Wildlife Management, etc.) regularly publish studies concerning contaminant effects on wildlife. Selected data from these sources are presented in tabular form in Appendix C. Pesticides were excluded from this compilation except for those considered to be likely contaminants on DOE reservations, such as the persistent organochlorine compounds (e.g., Chlordane, DDT, Endrin, etc.). Most of the available information on the effects of environmental contaminants on wildlife pertains to agricultural pesticides and little to industrial and laboratory chemicals of concern to DOE. Furthermore, the toxicity data that are available are often limited to severe effects of acute exposures [e.g., concentration or dose levels causing 50% mortality to a test population (LC_{50} and LD_{50})]. Relatively few studies have determined safe exposure levels (no-observed-adverse-effect-levels, or NOAELs) for situations in which wildlife have been exposed over an entire lifetime or over several generations. [In this document, NOAEL refers to both dose (mg contaminant per kg animal body weight per day) and concentration (mg contaminant per kg of food or L of drinking water)]. Consequently, for nearly all wildlife species, a NOAEL for chronic exposures to a particular chemical must be estimated from toxicity studies of the same chemical conducted on a different species of wildlife or on domestic or laboratory animals or from less than ideal data (e.g., LD_{50} values). In many cases, the only available information is from studies on laboratory species (primarily rats and mice). These studies may be of short-term or subchronic duration and may only identify a lowest-observed-adverse-effect-level (LOAEL) and not a NOAEL. Estimating a NOAEL for a chronic exposure from such data can introduce varying levels of uncertainty into the calculation (see Subsect. 3.2); however, such laboratory studies represent a valuable resource whose use should be maximized.

Wildlife NOAELs estimated from data on laboratory animals must be evaluated carefully, bearing in mind the possible limitations of the data. Variations may exist among species in physiological or biochemical factors such as uptake, metabolism, and disposition, which can alter the potential toxicity of a contaminant to a particular species. Inbred laboratory strains may have an unusual sensitivity or resistance to the tested compound. Behavioral and ecological parameters (e.g., stress factors such as competition, seasonal changes in temperature or food availability, diseased states, or exposure to other contaminants) may make a wildlife species' sensitivity to an environmental contaminant different from that of a laboratory or domestic species.

Available studies on wildlife or laboratory species may not include evaluations of all significant endpoints for determining long-term effects on natural populations. Important data that may be lacking are potential effects on reproduction, development, and population dynamics following multigeneration exposures. In this report, endpoints such as reproductive and developmental toxicity, and reduced survival were used whenever possible; however, for some contaminants, limitations in the available data necessitated the use of endpoints such as organ-specific toxic effects. It should be emphasized that in such cases the resulting benchmarks represent very conservative values whose relationship to potential population level effects is uncertain. These benchmarks will be recalculated if and when more appropriate toxicity data become available.

The fewer steps in the extrapolation process, the lower the uncertainty in estimating the wildlife NOAEL. For example, extrapolating from a NOAEL for an appropriate toxic endpoint (i.e., reproductive or population effects) for white laboratory mice to white-footed mice that are relatively closely related and of comparable body size would have a high level of reliability. Conversely, extrapolating from a LOAEL for organ-specific toxicity (e.g., liver or kidney damage) in laboratory mice to a non-rodent wildlife species such as mink or fox would have a low level of reliability in predicting population effects among these species. Because of the differences in avian and mammalian physiology and to reduce extrapolation uncertainty, studies performed on mammalian test species are used exclusively to estimate NOAELs for mammalian wildlife and studies performed on avian test species are used exclusively to estimate NOAELs for avian wildlife; interclass extrapolations were not performed.

In this report, benchmarks for mammalian species of wildlife have been estimated from studies conducted primarily on laboratory rodents, and benchmarks for avian species have been estimated from studies on domestic and wild birds. Very few experimental toxicity data are available for other groups of wildlife such as reptiles and amphibians, and it is not considered appropriate to apply benchmarks across different groups. Models for such wildlife extrapolations have not been developed as they have for aquatic biota (Suter, 1993).

3. METHODOLOGY

The general method used in this report is one based on EPA methodology for deriving human toxicity values (e.g., Reference Values, Reportable Quantities, and unit risks for carcinogenicity) from animal data (EPA, 1986a, 1986b, 1988b, 1989). In the method used herein experimentally derived NOAELs or LOAELs are used to estimate NOAELs for wildlife by adjusting the dose according to differences in body size. The concentrations of the contaminant in the wildlife species' food or drinking water that would be equivalent to the NOAEL are then estimated from the species' rate of food consumption and water intake. For wildlife species that feed primarily on aquatic organisms, a benchmark that combines exposure through both food and water is also calculated based on the potential of the contaminant to bioconcentrate and bioaccumulate through the food chain.

NOAELs and LOAELs for mammals and domestic and wild birds were obtained from the primary literature, EPA review documents, and secondary sources such as the Registry of Toxic Effects of Chemical Substances and the Integrated Risk Information System (IRIS). These studies are briefly described and the rationale for their use in deriving benchmarks is discussed in Appendix A. The selection of a particular study and a particular toxicity endpoint and the identification of NOAELs and LOAELs was based on our evaluation of the data. Emphasis was placed on those studies in which reproductive and developmental endpoints were considered (endpoints that may be directly related to potential population-level effects), multiple exposure levels were investigated, and the reported results were evaluated statistically to identify significant differences from control values. It is recognized that other interpretations of the same data may be possible and future research may provide more comprehensive data from which benchmarks might be derived. Therefore, it is anticipated that the development of these screening benchmarks will be an ongoing process and, consequently, the values presented in this report are subject to change.

3.1 ESTIMATING NOAELS FOR WILDLIFE

NOAELs and LOAELs are daily dose levels normalized to the body weight of the test animals (e.g., milligrams of chemical per kilogram body weight per day). The presentation of toxicity data on a mg/kg/day basis allows comparisons across tests and across species with appropriate consideration for differences in body size. Studies have shown that numerous physiological functions such as metabolic rates, as well as responses to toxic chemicals, are a function of body size. Smaller animals have higher metabolic rates and are usually more resistant to toxic chemicals because of more rapid rates of detoxification. (However, this may not be the case if the toxic effects of the compound are produced primarily by a metabolite). It has been shown that the best measure of differences in body size is one based on body surface area which, for lack of direct measurements, can be expressed in terms of body weight (bw) raised to the 2/3 power ($bw^{2/3}$) (EPA, 1980a). If the dose (d) itself has been calculated in terms of unit body weight (i.e., mg/kg), then the dose per unit body surface area (D) equates to:

$$D = \frac{d \ x \ bw}{bw^{2/3}} = d \ x \ bw^{1/3} \tag{1}$$

The assumption is that the dose per body surface area (Equation 1) for species "a" and "b" would be equivalent:

$$d_a \ x \ bw_a^{1/3} = d_b \ x \ bw_b^{1/3} \tag{2}$$

Therefore, knowing the body weights of two species and the dose (d_b) producing a given effect in species "b," the dose (d_a) producing the same effect in species "a" can be determined:

$$d_a = d_b \ x \ \frac{bw_b^{1/3}}{bw_a^{1/3}} = d_b \ x \left(\frac{bw_b}{bw_a}\right)^{1/3} \tag{3}$$

This is the methodology that EPA uses in carcinogenicity assessments and reportable quantity documents for adjusting from animal data to an equivalent human dose (EPA, 1985a, 1988b). The same approach has been proposed for use in extrapolating from one animal species to another. However, it should be noted that this method has not been applied to wildlife by the EPA and that wildlife toxicologists commonly scale dose to body weight without incorporating the exponential factor of 2/3. The exponent has been retained for this report because no reason exists why different methods should be used to extrapolate from mice to humans and mice to foxes. The issue of appropriate scaling models for wildlife should be investigated.

For developing reference doses (RfDs), EPA uses a default factor of 0.1 to adjust an animal dose to an equivalent human dose. Using the body size scaling method outlined previously results in an adjustment factor of about 0.07 when deriving an equivalent human dose from data for mice (using the standard body weight of 0.03 kg for mice and 70 kg for humans) and a factor of about 0.17 when deriving an equivalent human dose from data for rats (standard body weight 0.35 kg).

The ideal data set to use in the calculation would be the actual average body weights of the test animals used in the bioassay. When this information is not available, standard reference body weights for laboratory species can be used as indicated previously (EPA, 1985a, see Table 1). Body weight data for wildlife species are available from several secondary sources [i.e., the Mammalian Species series, published by the American Society of Mammalogists, Burt and Grosseneider, 1976; Dunning, 1984; Whitaker, 1980]. Often, only a range of adult body weight values is available for a species, in which case an average value must be estimated. A time-weighted average body weight for the entire life span of a species would be the most appropriate data set to use for chronic exposure situations; however, such data are usually not available. Body weight of a species can also vary geographically, as well as by sex. Sex-specific data may be needed depending on the toxicity endpoints used. Body weight data for the mammalian wildlife species considered in this report are given in Table 1.

Table 1. Reference values for mammalian species

Species	bw (kg)	Food Intake (kg/day)	Food factor[a] f	Water Intake (L/day)[19]	Water factor[b] ω
rat	0.35[c]	0.028[d]	0.08	0.046[e]	0.13
mouse	0.03[c]	0.0055[d]	0.18	0.0075[e]	0.25
rabbit	3.8[c]	0.135[d]	0.034	0.268[e]	0.070
dog	12.7[c]	0.301[d]	0.024	0.652[e]	0.051
short-tailed shrew	0.015[f]	0.009[f]	0.6	0.0033[f]	0.22
meadow vole	0.044[f]	0.005[f]	0.114	0.006[g]	0.136
white-footed mouse	0.022[f]	0.0034[f]	0.155	0.0066[f]	0.3
cotton rat	0.15	0.010[h]	0.07	0.018[g]	0.12
cottontail rabbit	1.2[f]	0.237[f]	0.198	0.116[g]	0.013
mink	1.0[f]	0.137[f]	0.137	0.099[g]	0.099
red fox	4.5[f]	0.45[f]	0.1	0.38[g]	0.084
whitetail deer	56.5[f]	1.74[f]	0.031	3.7[g]	0.065

[a] The food factor is the daily food intake divided by the body weight.
[b] The water factor is the daily water intake divided by the body weight.
[c] EPA reference values (EPA, 1985a).
[d] Calculated using reference body weight and Equation 10.
[e] Calculated using reference body weight and Equation 21.
[f] see Appendix B for data source.
[g] Calculated according to Calder and Braun, 1983; see Equation 24.
[h] Calculated using Equation 14.

If a NOAEL is available for the test species ($NOAEL_t$), then the equivalent NOAEL for a species of wildlife ($NOAEL_w$) can be calculated by using the adjustment factor for differences in body size:

$$NOAEL_w = NOAEL_t \left(\frac{bw_t}{bw_w} \right)^{1/4} \qquad (4)$$

3.2 DERIVING A CHRONIC NOAEL FROM OTHER ENDPOINTS

In cases where a NOAEL for a specific chemical is not available for either wildlife or laboratory species, but a LOAEL has been determined experimentally, the NOAEL can be estimated by applying an uncertainty factor (UF) to the LOAEL. In the EPA methodology, the LOAEL can be reduced by a factor of up to 10 to derive the NOAEL.

$$NOAEL = \frac{LOAEL}{\leq 10} \qquad (5)$$

Although a factor of 10 is usually used in the calculation, the true NOAEL may be only slightly lower than the experimental LOAEL, particularly if the observed effect is of low severity. A thorough analysis of the available data for the dose-response function may reveal whether a LOAEL to NOAEL uncertainty factor of < 10 should be used. No data were found for any of the contaminants considered suggesting the use of a LOAEL-NOAEL adjustment factor of less than 10.

If the only available data consist of a NOAEL (or a LOAEL) for a subchronic exposure, then the equivalent NOAEL or LOAEL for a chronic exposure can be estimated by applying a UF of $\leq$ 10:

$$chronic\ NOAEL = \frac{subchronic\ NOAEL}{\leq 10} \qquad (6)$$

EPA has no clear guidance on the dividing line between a subchronic exposure and a chronic exposure. For studies on laboratory rodents, EPA generally accepts a 90-day exposure duration as a standard for a subchronic exposure. In the guidance for the proposed Great Lakes Water Quality Criteria, EPA (1993d) indicates that a chronic exposure would be equivalent to at least 50% of a species lifespan. Since most of the NOAELS and LOAELS available for calculated benchmarks for mammalian wildlife are from studies on laboratory rodents (with lifespans of approximately 2 years), we have selected 1 year as the minimum required exposure duration for a chronic exposure (approximately one-half of the lifespan). There is little information concerning the lifespans of birds used in toxicity tests and little standardization of study duration for avian toxicity tests. In addition, few long-term, multigeneration avian toxicity tests have been performed. Therefore avian studies where exposure duration was 10 weeks or less were considered to be subchronic and those where the exposure duration was greater than 10 weeks were considered chronic studies.

In addition to duration of exposure, the time when contaminant exposure occurs is critical. Reproduction is a particularly sensitive lifestage due to the stressed condition of the adults and the rapid growth and differentiation occurring within the embryo. For many species, contaminant exposure of a few days to as little as a few hours during gestation and embryo development may produce severe adverse effects. Because these benchmarks are intended to evaluate the potential for adverse effects on wildlife populations and impaired reproduction is likely to affect populations, contaminant exposures that are less than one year or 10 weeks but occur during reproduction were considered to represent chronic exposures.

If the available data are limited to acute toxicity endpoints (FEL, frank-effects level) or to exposure levels associated with lethal effects (LD_{50}s), the estimation of NOAELs for chronic exposures are likely to have a wide margin of error because no standardized mathematical correlation exists between FEL or LD_{50} values and NOAELs that can routinely be applied to all chemicals (i.e., exposure levels associated with NOAELs may range from 1/10 to 1/10,000 of the acutely toxic dose, depending on the chemical and species). However, if both an LD_{50} and a NOAEL have been determined for a related chemical a, then this ratio could be used to estimate a $NOAEL_w$ using the $(LD_{50})_w$ for the compound of interest.

$$NOAEL_w = (LD_{50})_w \frac{NOAEL_a}{(LD_{50})_a} \tag{7}$$

3.3 NOAEL EQUIVALENT CONCENTRATION IN FOOD

The dietary level or concentration in food (C_f, in mg/kg food) of a contaminant that would result in a dose equivalent to the NOAEL (assuming no other exposure through other environmental media) can be calculated from the food factor f:

$$C_f = \frac{NOAEL_w}{f} \tag{8}$$

The food factor, f, is the amount of food consumed (F, in g/day or kg/day) per unit body weight (bw, in g or kg):

$$f = \frac{F}{bw} \tag{9}$$

In the absence of empirical data, rates of food consumption (F, in kg/day) for laboratory mammals can be estimated from allometric regression models based on body weight (in kg) (EPA, 1988a):

$$F = 0.056(bw)^{0.6611} \quad \textit{(laboratory mammals)} \tag{10}$$

$$F = 0.054(bw)^{0.9451} \quad \textit{(moist diet)} \tag{11}$$

$$F = 0.049(bw)^{0.6087} \quad \textit{(dry diet)} \tag{12}$$

In the absence of specific information on the body weights of the test animals, EPA (1985a) uses default values (see Table 1). In this report, F was estimated using Equation 10 and the default body weights. Reference body weights for particular strains of laboratory animals and for specific age groups corresponding to subchronic or chronic exposures are available (EPA, 1988a), and these can also be used in the equations. Default values for food consumption and food factors for common laboratory species (rats, mice, dogs, rabbits, etc.) have also been used by EPA (1988b) for estimating equivalent dose levels for laboratory studies in which the exposure is reported only as a dietary concentration. Generally, the rates of food consumption for laboratory species, as derived from Equations 10-12, are higher then the EPA default values.

Food consumption rates are available for some species of wildlife (EPA, 1993a, 1993b Table 1). In the absence of experimental data, F values (g/day) can be estimated from allometric regression models based on metabolic rate and expressed in terms of body weight (g) (Nagy, 1987):

$$F = 0.235(bw)^{0.822} \quad \textit{(placental mammals)} \tag{13}$$

$$F = 0.621(bw)^{0.564} \quad \textit{(rodents)} \tag{14}$$

$$F = 0.577(bw)^{0.727} \quad \textit{(herbivores)} \tag{15}$$

$$F = 0.492(bw)^{0.673} \quad (marsupials) \tag{16}$$

$$F = 0.648(bw)^{0.651} \quad (birds) \tag{17}$$

$$F = 0.398(bw)^{0.850} \quad (passerine\ birds) \tag{18}$$

3.4 NOAEL EQUIVALENT CONCENTRATION IN DRINKING WATER

The concentration of the contaminant in the drinking water of an animal (C_w, in mg/L) resulting in a dose equivalent to a $NOAEL_w$ can be calculated from the daily water consumption rate (W, in L/day) and the average body weight (bw_w) for the species:

$$C_w = \frac{NOAEL_w \ x \ bw_w}{W} \tag{19}$$

If known, the water factor ω (= the rate of water consumption per unit body weight (W/bw) can be used in a manner identical to that for the food factor.

$$C_w = \frac{NOAEL_w}{\omega} \tag{20}$$

If empirical data are not available, W (in L/day) can be estimated from allometric regression models based on body weight (in kg) (EPA, 1988a):

$$W = 0.10(bw)^{0.7377} \quad (laboratory\ mammals) \tag{21}$$

$$W = 0.009(bw)^{1.2044} \quad (mammals,\ moist\ diet) \tag{22}$$

$$W = 0.093(bw)^{0.7584} \quad (mammals,\ dry\ diet) \tag{23}$$

In the absence of specific information on the body weights of the test animals, EPA (1985a) uses default values (see Table 1). In this report, W was estimated using Equation 21 and the default body weights. Reference body weights for particular strains of laboratory animals and for specific age groups corresponding to subchronic or chronic exposures are available (EPA, 1988a), and these can also be used in the equations. Default values for water consumption and ω for common laboratory species have been used by EPA (1988b) for estimating equivalent dose levels for laboratory studies in which the exposure was given only as a concentration in the animals' drinking water. Generally, the rates of water consumption for laboratory species, as derived from Equations 21-23, are higher then the EPA default values.

Water consumption rates are available for some species of mammalian wildlife (Table 1). Water consumption rates (in L/day) can also be estimated from allometric regression models based on body weight (in kg) (Calder and Braun, 1983):

$$W = 0.099(bw)^{0.90} \tag{24}$$

A similar model has also been developed for birds (Calder and Braun, 1983):

$$W = 0.059(bw)^{0.67} \tag{25}$$

3.5 COMBINED FOOD AND WATER BENCHMARKS FOR AQUATIC FEEDING SPECIES

If a wildlife species (such as mink, belted kingfisher, or great blue heron) feeds primarily on aquatic organisms and the concentration of the contaminant in the food is proportional to the concentration in the water, then the food consumption rate (F, in kg/day) and the aquatic life bioaccumulation factor can be used to derive a C_w value that incorporates both water and food consumption (EPA, 1993c, 1993d, 1993e):

$$C_w = \frac{NOAEL_w \ x \ bw_w}{W + (F \ x \ BAF)} \tag{26}$$

The BAF is the ratio of the concentration of a contaminant in tissue (mg/kg) to its concentration in water (mg/L), where both the organism and its prey are exposed, and is expressed as L/kg. Bioaccumulation factors may be predicted by multiplying the bioconcentration factor for the contaminant [BCF, ratio of concentration in food to concentration in water; i.e., (mg/kg)/(mg/L) = L/kg] by the appropriate food chain multiplying factor (FCM) (see Table 2). For most inorganic compounds, BCFs and BAFs are assumed to equal; however, an FCM may be applicable for some metals if the organometallic form biomagnifies (EPA, 1993c).

Table 2. Aquatic food chain multiplying factors[a]

Log P_{oct}	Prey Trophic Level[b] 2	3	4
≤3.9	1.0	1.0	1.0
4.0	1.1	1.0	1.0
4.1	1.1	1.1	1.1
4.2	1.1	1.1	1.1
4.3	1.1	1.1	1.1
4.4	1.2	1.1	1.1
4.5	1.2	1.2	1.2
4.6	1.2	1.3	1.3
4.7	1.3	1.4	1.4
4.8	1.4	1.5	1.6
4.9	1.5	1.8	2.0
5.0	1.6	2.1	2.6
5.1	1.7	2.5	3.2
5.2	1.9	3.0	4.3
5.3	2.2	3.7	5.8
5.4	2.4	4.6	8.0
5.5	2.8	5.9	11.0
5.6	3.3	7.5	16.0
5.7	3.9	9.8	23.0
5.8	4.6	13.0	33.0
5.9	5.6	17.0	47.0
6.0	6.8	21.0	67.0
6.1	8.2	25.0	75.0
6.2	10.0	29.0	84.0
6.3	13.0	34.0	92.0
6.4	15.0	39.0	98.0

Table 2. (continued)

Log P_{oct}	Prey Trophic Level[b]		
	2	3	4
≤3.9	1.0	1.0	1.0
6.5	19.0	45.0	100.0
>6.5	([c])	([c])	([c])

[a]From U.S. EPA 1993c.
[b]Trophic level: 2 = zooplankton; 3 = small fish; 4 = piscivorous fish, including top predators.
[c]For chemicals with log P_{oct}>6.5, FCM can range from 0.1-100. Such chemicals should be evaluated individually. Without chemical-specific data, an FCM of 1.0 should be used (EPA 1993c).

In cases where the BCF for a particular compound is not available, it can be estimated from the octanol-water partition coefficient of the compound by the following relationship (Lyman et al., 1982):

$$\log BCF = 0.76 \log P_{oct} - 0.23 \qquad (27)$$

The BCF can also be estimated from the water solubility of a compound by the following regression equation (Lyman et al., 1982):

$$\log BCF = 2.791 - 0.564 \log WS \qquad (28)$$

where WS is the water solubility in mg/L water.

Log P_{oct} values, reported or calculated BCF values, and estimated BAF values for chemicals for which benchmarks have been derived are included on Table 3. Reported BCFs represent the maximum value listed for fish. A FCM of 1 was applied to all reported BCFs for inorganic compounds (EPA, 1993c). Because all wildlife (mink, belted kingfisher, great blue heron), for which combined food and water benchmarks were calculated, consume small fish, the trophic level 3 FCM appropriate for the log P_{oct} of the chemical was applied to all calculated BCFs.

Table 3. Octanol-water partition coefficients, bioconcentration factors, and bioaccumulation factors for selected chemicals

Chemical and Form	Log P_{oct}	BCF	Trophic Level 3 FCM	Trophic Level 3 BAF	Source
Acetone	-0.24	0.39[a]	1.0	0.39	USAF 1989
Aluminum		231	1.0	231.00	EPA 1988c
Antimony		1	1.0	1.00	EPA 1980b
Aroclor 1016	5.6	10616.9[a]	7.5	79627.17	ATSDR 1989
Aroclor 1242	5.6	10616.9[a]	7.5	79627.17	ATSDR 1989
Aroclor 1248	6.2	30338.9[a]	29.0	879828.44	ATSDR 1989
Aroclor 1254	6.5	51286.1[a]	45.0	2307876.23	ATSDR 1989
Arsenic (arsenite)		17.00	1.0	17.00	EPA 1985g
Benzene	2.13	24.48[a]	1.0	24.48	EPA 1992
BHC-mixed isomers	5.31	6391.46[a]	3.7	23648.40	EPA 1992
Benzo(a)pyrene	6.1	25468.3[a]	25.0	636707.56	EPA 1992
Beryllium		19.00	1.0	19.00	EPA 1980c
Bis(2-ethylhexyl)phthalate	5.11	4504.0[a]	2.5	11260.04	EPA 1992
Cadmium		12400.00	1.0	12400.00	EPA 1985f
Carbon Tetrachloride	2.83	83.33[a]	1.0	83.33	EPA 1992
Chlordane	5.54	9558.73[a]	5.9	56396.48	EPA 1992
Chloroform	1.97	18.5[a]	1.0	18.50	EPA 1992
Chromium (Cr+6)		3.00	1.0	3.00	EPA 1985d
Copper		290.00	1.0	290.00	EPA 1985e
o-Cresol	1.95	17.86[a]	1.0	17.86	EPA 1992
Cyanide		0.00	1.0	0.00	EPA 1985c
DDT (and metabolites)	6.36	40142.1[a]	39.0	1565541.58	EPA 1992
1,2-Dichloroethane	1.48	7.85[a]	1.0	7.85	EPA 1992
1,1-Dichloroethylene	2.13	24.48[a]	1.0	24.48	EPA 1992
1,2-Dichloroethylene	1.86	15.26[a]	1.0	15.26	EPA 1992
Dieldrin	4.56	1720.28[a]	1.3	2236.37	EPA 1992
Diethylphthalate	2.47	44.38[a]	1.0	44.38	EPA 1992
Di-n-butyl phthalate	4.13	810.59[a]	1.1	891.65	EPA 1992
1,4-Dioxane	-0.27	0.37[a]	1.0	0.37	EPA 1992
Endrin	4.56	1720.28[a]	1.3	2236.37	EPA 1992
Ethanol	-0.31	0.34[a]	1.0	0.34	EPA 1992
Formaldehyde	0.35	1.09[a]	1.0	1.09	EPA 1992

Table 3. (continued)

Chemical and Form	Log P_{ow}	BCF	Trophic Level 3 FCM	Trophic Level 3 BAF	Source
Acetone	-0.24	0.39*	1.0	0.39	USAF 1989
Heptachlor	4.27	1035.62*	1.1	1139.18	EPA 1992
Lead		45.00	1.0	45.00	EPA 1985b
Lindane (Gamma-BHC)	3.72	395.55*	1.0	395.55	EPA 1992
Mercury (Methyl Mercury Chloride)				60000.00	EPA 1993e
Methanol	-0.77	0.15*	1.0	0.15	EPA 1992
Methylene Chloride	1.25	5.25*	1.0	5.25	EPA 1992
Methyl Ethyl Ketone	0.29	0.98*	1.0	0.98	EPA 1992
4-Methyl 2-Pentanone	1.19	4.72*	1.0	4.72	EPA 1992
Nickel		106.00	1.0		EPA 1986f
Pentachloronitrobenzene	4.64	1978.79*	1.3	2572.43	EPA 1992
Selenium				2600.00	Peterson and Nebeker 1992
2,3,7,8-Tetrachloro Dibenzodioxin	6.8	86696.2*	1.0	86696.19	EPA 1992
1,1,2,2-Tetrachloroethylene	3.4	225.94*	1.0	225.94	EPA 1992
Thallium		34.00	1.0	34.00	EPA 1980d
Toluene	2.73	69.95*	1.0	69.95	EPA 1992
Toxaphene	4.82	2711.44*	1.5	4067.16	EPA 1992
1,1,1-Trichloroethane	2.49	45.96*	1.0	45.96	EPA 1992
Trichloroethylene	2.42	40.66*	1.0	40.66	EPA 1992
Vinyl Chloride	1.36	6.36*	1.0	6.36	EPA 1992
Xylene (mixed isomers)	3.2	159.22*	1.0	159.22	EPA 1992
Zinc		966.00	1	966.00	EPA 1987

* Values estimated using Equation 27

4. APPLICATION OF THE METHODOLOGY

Two examples will be given illustrating the application of the methodology for deriving NOAELs and screening benchmarks. In one example (inorganic trivalent arsenic), the estimated values were derived primarily from data on laboratory species. In the second example (Aroclor 1254, a polychlorinated biphenyl), experimental data were available for two species of mammalian wildlife. While the examples focus on mammals, derivation of NOAELs and screening benchmarks for birds is performed in an identical manner.

4.1 INORGANIC TRIVALENT ARSENIC

The toxicity of inorganic compounds containing arsenic depends on the valence or oxidation state of the arsenic as well as on the physical and chemical properties of the compound in which it occurs. Trivalent (As^{+3}) compounds such as arsenic trioxide (As_2O_3), arsenic trisulfide (As_2S_3), and sodium arsenite ($NaAsO_2$), are generally more toxic than pentavalent (As^{+5}) compounds such as arsenic pentoxide (As_2O_5), sodium arsenate (Na_2HAsO_4), and calcium arsenate [$Ca_3(AsO_4)_2$]. The relative toxicity of the trivalent and pentavalent forms may also be affected by factors such as water solubility; the more toxic compounds are generally more water soluble. In this analysis, the effects of the trivalent form of arsenic in water soluble inorganic compounds will be evaluated. In many cases, only total arsenic concentrations are reported so the assessor must conservatively assume that it is all trivalent.

4.1.1 Toxicity to Wildlife

The only wildlife toxicity information available for trivalent inorganic arsenic compounds pertains to acute exposures (Table 4; the values listed are those reported in the literature except where noted).

For whitetail deer, the estimated lethal dose is 34 mg sodium arsenite/kg or 19.5 mg As/kg (NAS, 1977). For birds, estimated LD_{50} values for sodium arsenite range from 47.6 to 386 mg/kg body weight. Median lethality was also reported at a dietary level of 500 mg/kg food for mallard ducks. No information was found in the available literature regarding chronic toxicity or reproductive or developmental effects.

4.1.2 Toxicity to Domestic Animals

The toxicity of inorganic trivalent arsenic to domestic animals is summarized in Table 5 (the values listed are those given in the source). For assessment purposes, the most useful study is the one identifying a dietary NOAEL of 50 ppm As in dogs following a 2 year exposure to sodium arsenite. This dietary concentration was estimated to be equivalent to 1.2 mg/kg bw/day.

4.1.3 Toxicity to Laboratory Animals (Rodents)

Selected acute and chronic toxicity data for trivalent arsenic in rats and mice are summarized in Table 6 (dietary or drinking water concentrations were converted to daily dose levels using reference body weights and Equations 8 and 20). For assessment purposes, the studies of Byron et al. (1967) and that of Schroeder and Mitchener (1971) provide the most useful data. In the study of Bryon et al. (1967), a dietary concentration of 62.5 ppm As for 2 years caused no adverse effects in rats other than a slight reduction in growth of females. This dietary level, which can be considered a NOAEL, is equivalent to a daily dose of 5 mg As/kg bw/day. In the Schroeder and Mitchener (1971) study, a concentration of 5 mg As/L in the drinking water of mice over three generations was associated with a decrease in litter size and therefore is considered a potential population level LOAEL. The equivalent dose was estimated to be 1.26 mg/kg bw/day; therefore, using Equation 5, the NOAEL is estimated to be 0.126 mg/kg bw/day.

Table 4. Toxicity of trivalent arsenic compounds to wildlife[a]

Species	Chemical	Conc. in Diet (mg/kg food)	Dose (mg/kg)	Effect	Reference
Whitetail deer *(Odocoileus virginianus)*	sodium arsenite	NR	34	Lethal dose	NAS, 1977
Mallard duck *(Anas platyrhynchos)*	sodium arsenite	NR	323	LD_{50} (single dose)	NAS, 1977
	sodium arsenite	500	NR	32-day LD_{50}	NAS, 1977
California quail *(Callipepla californica)*	sodium arsenite	NR	47.6	LD_{50}	Hudson et al., 1984
Ring-necked pheasant *(Phasianus colchicus)*	sodium arsenite	NR	386	LD_{50} (single dose)	Hudson et al., 1984

[a] Source of data and references: Eisler, 1988. NR. Not reported.

Table 5. Toxicity of trivalent arsenic compounds to domestic animals[a]

Species	Chemical	Conc. in Diet[b] or Water[c]	Dose[d]	Effect	Reference
Cattle	arsenic trioxide	NR	33–55 mg/kg (single dose)	toxic	Robertson et al., 1984
	sodium arsenite	NR	1–4 g/animal	lethal	NRCC, 1978
Sheep	sodium arsenite	NR	5–12 mg/kg (single dose)	acutely toxic	NRCC, 1978
	"total arsenic"	58 mg As/kg food (3 wk)	NR	no adverse effects	Woolson, 1975
Horse	sodium arsenite	NR	2–6 mg/kg/day (14 wk)	lethal	NRCC, 1978
Pig	sodium arsenite	500 mg As/L	100–200 mg/kg	lethal	NAS, 1977
Cat	arsenite	NR	1.5 mg/kg/day	chronic toxic effects	Pershagen and Vahter, 1979
Dog	sodium arsenite	NR	50–150 mg/animal	lethal	NRCC, 1978
	sodium arsenite	125 mg As/kg food (2 year)	3.0 mg As/kg/day[e]	reduced survival	Byron et al., 1967
	sodium arsenite	50 mg As/kg food (2 year)	1.2 mg As/kg/day[e]	NOAEL	Byron et al., 1967

Table 5. (continued)

Species	Chemical	Conc. in Diet[b] or Water[c]	Dose[d]	Effect	Reference
	sodium arsenite	NR	4 mg/kg/day (58 days) + 8 mg/kg (125 days)	LOAEL; liver enzyme changes	Neiger and Osweiler, 1989
Mammals	arsenic trioxide	NR	3–250 mg/kg	lethal	NAS, 1977
Mammals	sodium arsenite	NR	1–25 mg/kg	lethal	NAS, 1977
Chicken *(Gallus gallus)*	arsenite	NR	0.01–1.0 μg As/embryo	≤34% dead	NRCC, 1978
	arsenite	NR	0.03–0.3 μg As/embryo	malform.	NRCC, 1978

[a] Sources of data and references: USAF, 1990; Eisler, 1988. NR Not reported.
[b] Dietary level given as mg/kg food.
[c] Concentration in water given as mg/L.
[d] Dose, in mg/kg bw/day, refers to compound unless otherwise stated.
[e] Calculated using body weight of 12.7 kg and Equations 8, 9 and 10.

Table 6. Toxicity of trivalent arsenic compounds to laboratory animals

Species	Chemical	Conc. in Diet[a] or Water[b]	Dose (mg As/kg)	Effect	Reference
Rat	arsenic trioxide	NR	15.1 (1 dose)	LD_{50}	Harrison et al., 1958
	sodium arsenite	125 mg As/kg food (2 year)	10[c]	FEL, bile duct enlargement	Byron et al., 1967
	sodium arsenite	62.5 mg As/kg food (2 year)	5[c]	reduced growth in females; no effect on survival	Byron et al., 1967
	sodium arsenite	31.25 mg As/kg food (2 year)	2.5[c]	NOAEL	Byron et al., 1967
	sodium arsenite	5 mg As/L (lifetime)	0.65[d]	NOAEL	Schroeder et al., 1968a
Mouse	arsenic trioxide	NR	39.4 (1 dose)	LD_{50}	Harrison et al., 1958
	sodium arsenite	NR	a. 23 (1 dose) b. 11.5 (1 dose)	a. Fetal mortality b. NOAEL	Baxley et al., 1981
	arsenic trioxide	75.8 mg As/L (lifetime)	18.95[d]	LOAEL; mild hyperkeratosis/epidermal hyperplasia	Baroni et al., 1963
	soluble arsenite	5 mg As/L + 0.06 mg As/kg food (3 generations)	1.26[c,d]	LOAEL; incr. in male to female ratio; decr. in litter size	Schroeder and Mitchener, 1971

Table 6. (continued)

Species	Chemical	Conc. in Diet[a] or Water[b]	Dose (mg As/kg)	Effect	Reference
	sodium arsenite	5 mg As/L + 0.46 mg As/kg food (lifetime)	$0.44^{c,d}$	LOAEL; slight decr. in median life span; no effect on growth	Schroeder and Balassa, 1967
	sodium arsenite	0.5 mg As/L (3 weeks)	0.125^{d}	LOAEL; immunosuppressive effects	Blakely et al., 1980

[a] Dietary level in mg/kg food.
[b] Concentration in water given as mg/L.
[c] Estimated using reference body weight (see Table 1) and Equations 8, 9, and 10.
[d] Estimated using reference body weight (see Table 1) and Equations 19, 20 and 21.

4.1.4 Extrapolations to Wildlife Species

Estimates of benchmarks for wildlife are shown in Table 7. The values derived from laboratory studies are shaded. The NOAELs for dose (mg/kg bw/day) were estimated using Equation 4. Concentrations in food (C_f) equivalent to the NOAEL were calculated using the food factors listed in Table 1 and Equation 8. Similarly, concentrations in water (C_w) equivalent to the NOAELs were estimated from the water factors given in Table 1 and Equation 20.

Three of the toxicity values listed in Tables 5 and 6 were used to estimate benchmarks for wildlife; the drinking water LOAEL of 5 mg/L for mice (Schroeder and Mitchener, 1971); the dietary NOAEL of 62.5 ppm for rats (Byron et al., 1967); and a dietary NOAEL of 50 ppm for dogs (Bryon et al., 1967). These values were used to estimate NOAELs, C_f, and C_w for the white-footed mouse, cotton rat, red fox, and whitetail deer (Table 7). As expected, benchmarks derived from related species are similar because of similarities in body weight and food and water consumption. Wildlife benchmarks derived from the mouse study are substantially lower than the corresponding NOAELs, C_fs, and C_ws derived from the rat or dog studies. There may be several explanations for these differences. Mice may be unusually sensitive to trivalent arsenic; however, the LD_{50} data for rats and mice suggest a similar level of tolerance. The mouse study was a three-generation bioassay in which reproductive effects (reduced litter size) were identified. Although both the rat and dog studies involved chronic exposure durations, neither evaluated potential reproductive effects. Therefore, it is possible that reproductive effects similar to those seen in mice might occur in rats and dogs at or below the experimental NOAELs for these species if multigeneration studies were conducted. Another possibility is that trivalent arsenic may be relatively more toxic in drinking water than food, which might be the case if there were significant differences in rates of gastrointestinal absorption. If this can be shown to be the case,

Table 7. Selected wildlife toxicity values for trivalent inorganic arsenic[a,b]

Species	BW (kg)	Food factor f^c	Water factor w^c	LOAEL	NOAEL (as As) Dose (mg/kg)	NOAEL (as As) $C_f^{(8)}$ (mg/kg)	NOAEL (as As) $C_w^{(20)}$ (mg/L)	LD_{50} (mg As/kg)	$\frac{NOAEL}{LD_{50}}$
Mouse	0.030	0.18	0.25	3.0 mg/L + 0.06 mg/kg	0.126[20]	0.7	0.5[3]	39.4	0.002
White-footed mouse	0.022	0.155	0.3						
	Extrapolated from data for laboratory mice →				0.14[4]	0.9	0.47		
Rat	0.35	0.05	0.13		5[6]	62.5	38.5	15.1	0.21
Cotton rat	0.15	0.070[c,g]	0.12[c,h]						
	Extrapolated from data for laboratory rat →				6.6[4]	95	55		
	Extrapolated from data for laboratory mouse →				0.07[4]	1.0	0.6		
Dog	12.7	0.024	0.051		1.2[6]	50	26		
Red fox	4.5	0.1	0.084						
	Extrapolated from data for dog →				1.7[4]	17	20		
	Extrapolated from data for laboratory mouse →				0.024[4]	0.24	0.28		
Whitetail deer	56.5	0.031	0.065					>19.5	
	Extrapolated from data for laboratory rat →				0.9[4]	29	13.8		
	Extrapolated from data for dog →				0.73[4]	23.5	11.2		
	Extrapolated from data for laboratory mice →				0.01[4]	0.32	0.15		

[a] Numbers in parentheses refer to equations in text used to derive the values.
[b] Shaded values are experimentally derived. [c] see Table 1.

then benchmarks based on media-specific studies would be appropriate. Because there is insufficient information to determine which of these factors is responsible, the conservative approach would be to use the mouse data to estimate the benchmarks for the wildlife species.

4.2 POLYCHLORINATED BIPHENYLS

Polychlorinated biphenyls occur in a variety of different formulations consisting of mixtures of individual compounds. The most well-known of these formulations is the Aroclor series (i.e., Aroclor 1016, Aroclor 1242, Aroclor 1248, Aroclor 1254, etc.). The Aroclor formulations vary in the percent chlorine, and, generally, the higher the chlorine content the greater the toxicity. This analysis will focus on Aroclor 1254 for which chronic toxicity data are available for two species of wildlife.

4.2.1 Toxicity to Wildlife

Toxicity data for Aroclor 1254 are available for two species of wildlife: white-footed mice and mink (Table 8). In both species, the reproductive system and developing embryos are adversely affected by both acute and chronic exposures. A dietary LOAEL of 10 ppm was reported for white-footed mice (Linzey, 1987). Using Equation 5, a body weight of 0.22 kg (Table 1) and a food consumption rate of 3.4 g/day (Table 1), the estimated NOAEL for this species would be $\geq$0.155 mg/kg bw/day. A dietary NOAEL of 1 ppm was reported for mink (Aulerich and Ringer, 1977). Using a time-weighted average body weight of 0.8 kg (Bleavins et al. 1980) and a food consumption rate of 110 g/day (137 g/kg bw/day x 0.8 kg bw; Bleavins and Aulerich 1981), the NOAEL is 0.137 mg/kg/day.

4.2.2 Toxicity to Domestic Animals

No information was found in the available literature on the toxicity of Aroclor 1254 to domestic animals.

4.2.3 Toxicity to Laboratory Animals

As shown in Table 9, laboratory studies have identified a dietary NOAEL of 5 ppm (= 0.4 mg/kg bw/day) for rats exposed to Aroclor 1254 over two generations (Linder et al., 1974). Reported LOAELs are 4–10 times higher than the NOAEL, and the single-dose LD_{50} is about 4000-fold higher than the NOAEL. As shown by the dose levels that produce fetotoxicity during gestation, rabbits appear to be less sensitive than rats.

4.2.4 Extrapolations to Wildlife Species

Experimentally derived and extrapolated toxicity values for Aroclor 1254 for representative wildlife species are shown in Table 10. Empirical data are available for three species: laboratory rat (Linder et al., 1974), white-footed mouse (Linzey, 1987) and mink (Aulerich and Ringer, 1977). Reproductive and/or developmental changes were the endpoints evaluated in each of these studies.

Table 8. Toxicity of Aroclor 1254 to wildlife

Species	Concentration in Food	Daily Dose (mg/kg)	Expos. Period	Effect	Reference
White-footed mouse	400 ppm	62[a]	2-3 wk	FEL, reprod.	Sanders and Kirkpatrick, 1975
	200 ppm	31[a]	60 d	LOAEL, reproduction	Merson and Kirkpatrick, 1976
	10 ppm	1.55[a]	18 mo	LOAEL, reproduction	Linzey, 1987
mink	6.5 ppm	0.89[a]	9 mo	LC_{50}	Ringer et al., 1981; ATSDR, 1989
	2 ppm	0.38[b] 0.28[c]	9 mo	FEL/LOAEL, fetotoxicity	Aulerich and Ringer, 1977
	1 ppm	0.137[c]	5 mo	NOAEL	Aulerich and Ringer, 1977

[a] Estimated from Equation 8 using a food factor of 0.155.
[b] Reported by ATSDR (1989); based on food intake of 150 g/day and mean body weight of 0.8 kg
[c] Estimated a food consumption rate of 110 g/d and a body weight of 0.8 kg (as reported by Bleavins et al., 1980).

Table 9. Toxicity of Aroclor 1254 to laboratory animals

Species	Concentration in Diet	Daily Dose (mg/kg)	Exposure Period	Effect	Reference
Rat		1010	1 day	LD_{50}	Garthoff et al., 1981
	50 ppm	4[a]	During gestation	LOAEL, for fetotoxicity	Collins and Capen, 1980
	25 ppm	2[a]	104 week	LOAEL, reduced survival	NCI, 1978; ATSDR, 1989a
	20 ppm	1.6[a]	2 generations	FEL/LOAEL, reduced litter size	Linder et al., 1974
	5 ppm	0.4[a]	2 generations	NOAEL	Linder et al., 1974
Rabbit		10.0	During gestation (28 days)	NOAEL for fetoxicity	Villeneuve et al., 1971
		12.5	During gestation (28 days)	FEL, fetal deaths	Villeneuve et al., 1971

[a] Calculated using a food factor of 0.08 (see Table 1) and Equation 8.

Table 10. Selected wildlife toxicity values for Aroclor 1254[a,b]

Species	bw (kg)	Food factor f	Water factor ω	LOAEL (ppm diet)	NOAEL (mg/kg/d)	Benchmarks C_f (mg/kg food)	Benchmarks C_w (mg/L)	LD_{50} (mg/kg)	NOAEL/ LD_{50}
Rat (lab)	0.35	0.08	0.13		0.4[(8)]	5.0	3.1	1,010	0.0004
White-footed mouse	0.022	0.155	0.3	10	≥0.155[(8)]	1.0	0.52		
	Extrapolated from rat data →				1.01[(4)]	6.5[(8)]	3.35		
	Extrapolated from mink data →				0.45[(4)]	2.9[(8)]	1.50		
Mink	0.80[c]	0.137	0.099		0.137[(8)]	1	0.71	1.25	0.06
	Extrapolated from mouse data →				≥0.05[(4)]	0.34[(8)]	0.47[(20)]		
	Extrapolated from rat data →				0.30[(4)]	2.22[(8)]	3.08[(20)]		
Cotton rat:	0.15	0.07	0.12						
	Extrapolated from mouse data →				≥0.08[(4)]	1.17[(8)]	0.68[(20)]		
	Extrapolated from rat data →				0.53[(4)]	7.56[(8)]	4.41[(20)]		
	Extrapolated from mink data →				0.24[(4)]	3.4[(8)]	1.98[(20)]		
Whitetail deer:	56.5	0.031	0.065						
	Extrapolated from mouse data →				≥0.012[(4)]	0.37[(8)]	0.17[(20)]		
	Extrapolated from rat data →				0.075[(4)]	2.43[(8)]	1.14[(20)]		
	Extrapolated from mink data →				0.034[(4)]	1.09[(8)]	0.51[(20)]		

[a] Numbers in parentheses refer to equations in text.
[b] Shaded values are experimentally derived.
[c] TWA bw for females to 10 mo (reproductive maturity) (EPA, 1988a).

The calculated NOAELs are 0.4 mg/kg bw/day for the rat, 0.155 mg/kg bw/day for the white-footed mouse, and 0.137 mg/kg bw/day for mink. These data indicate that the laboratory rat is less sensitive to the toxicity of Aroclor 1254 than either the white-footed mouse or the mink.

The most conservative benchmark for Aroclor 1254 would be the NOAEL for whitetail deer (0.012 mg/kg bw/day) extrapolated from the data for the white-footed mouse. The NOAEL derived from the mink data (0.034 mg/kg) may be more reliable because it was based on an experimentally derived NOAEL whereas the white-footed mouse value was based on an experimentally derived LOAEL. However, because metabolism and physiology are more likely to be similar between an omnivore (mouse) and a herbivore (deer) than between a carnivore (mink) and herbivore, the white-footed mouse NOAEL may be a better estimate of toxicity to whitetail deer than the mink NOAEL.

For mink, a combined water quality benchmark for Aroclor 1254 can be derived from Equation 26. Using a log P_{oct} of 6.5 (ATSDR, 1989), the bioconcentration factor (BCF) for Aroclor 1254 was estimated from Equation 27 to be 51,286. Conservatively, the diet of mink is assumed to consist entirely of small fish (trophic level 3, FCM = 45.0; Table 2); therefore, the BAF was estimated to be 2,307,876. For mink weighing 0.8 kg and a NOAEL of 0.137 mg/kg, the combined food and water benchmark for Aroclor 1254 is calculated to be 0.43 ng/L.

5. SITE-SPECIFIC CONSIDERATIONS

The examples given in this report for trivalent inorganic arsenic and Aroclor 1254 illustrate the extent of the analysis that is required for an understanding of the toxicity of environmental contaminants to wildlife and for the development of benchmark values. For a complete risk assessment at a particular site, similar analyses would be needed for all the chemicals present, as well as information on their physical and chemical state, their concentration in various environmental media, and their bioavailability. The last factor is especially important in estimating environmental impacts. For example, insoluble substances tightly bound to soil particles are unlikely to be taken up by organisms even if ingested. In addition, the chemical or valence state of a contaminant may alter its toxicity such that the different chemical or valence states may have to be treated separately as in the case of trivalent arsenic. Similar problems can be encountered with formulations consisting of mixtures of compounds such as the Aroclors, and each may have to be evaluated separately, unless the relative potency of each of the components can be determined.

For a site-specific assessment, information on the types of wildlife species present, their average body size, and food and water consumption rates would also be needed for calculating NOAELs and environmental criteria. Use of observed values for food and water consumption (if available) are recommended over rates estimated by allometric equations. A list of pertinent exposure parameters (body weights, food and water consumption rates) for selected avian and mammalian species for the DOE Oak Ridge site is given in Appendix B. Exposure information for additional wildlife species may be found in Wildlife Exposure Factors Handbook (EPA, 1993a and 1993b). Since body size of some species can vary geographically, the more specific the data are to the local population, the more reliable will be the estimates. Data on body size are especially important in the extrapolation procedure, particularly if calculations of the NOAEL and environmental concentrations are based solely on the adjustment factor as shown in Equation 4. In such cases the lowest NOAEL will be derived from the species with the largest body size. Estimates of average body weights for wildlife species used herein were obtained from the available literature (Appendix B, see also Table 1). These were used to calculate body surface area scaling factors from Equation 4 (Table 11) and also to derive food factors from Equation 10 and water factors from Equations 21 (see Table 1).

Information on physiological, behavioral, or ecological characteristics of these species can also be of special importance in determining if certain species are particularly sensitive to a particular chemical or groups of chemicals. If one species occurring at a site is known to be unusually sensitive to a particular contaminant, then the criteria should be based on data for that species (with exceptions noted in the following paragraphs). Similarly, extrapolations from studies on laboratory animals should be based on the most sensitive species unless there is evidence that this species is unusually sensitive to the chemical.

Physiological and biochemical data may be important in determining the mechanism whereby a species' sensitivity to a chemical may be enhanced or diminished. Such information would aid in determining whether data for that species would be appropriate for developing criteria for other species.

For example, if the toxic effects of a chemical are related to the induction of a specific enzyme system, as is the case with PCBs, then it would be valuable to know whether physiological factors (enzyme activity levels per unit mass of tissue or rates of synthesis of the hormones affected by the induced enzymes) in the most sensitive species are significantly different from those of other species of wildlife. Furthermore, if the most sensitive species, or closely related species, do not occur at a particular site, then a less stringent criterion might be acceptable.

Physiological data may also reveal how rates of absorption and bioavailability vary with exposure routes and/or exposure conditions. Gastrointestinal absorption may be substantially different depending on whether the chemical is ingested in the diet or in drinking water. Therefore, a NOAEL based on a laboratory drinking water study may be inappropriate to use in extrapolating to natural populations that would only be exposed to the same chemical in their diet. The diet itself may affect gastrointestinal absorption rates. In the case of the mink exposed to PCBs, a diet consisting primarily of contaminated fish in which the PCBs are likely to be concentrated in fatty tissues may result in a different rate of gastrointestinal absorption than that occurring in laboratory rodents dosed with PCBs in dry chow.

Behavioral and ecological data might also explain differences in sensitivity between species. Certain species of wildlife may be more sensitive because of higher levels of environmental stress to which they are subjected. This may be especially true of populations occurring at the periphery of their normal geographic range. Conversely, laboratory animals maintained under stable environmental conditions of low stress may have higher levels of resistance to toxic chemicals.

As a first step in developing wildlife criteria for chemicals of concern at DOE sites, relevant toxicity data for wildlife and laboratory animals have been compiled (Appendixes A and C). These data consist primarily of NOAELs, LOAELs, and LD_{50}s for avian and mammalian species. No methodology is currently available for extrapolating from avian or mammalian studies to reptiles and amphibians, and no attempt has been made to do so in this report. No pertinent data on nonpesticide chemicals were found for amphibians, reptiles, or terrestrial invertebrates. Additional chronic exposure studies are needed before toxicological benchmarks can be developed for these groups.

6. RESULTS

The results of the analyses are presented in Table 12. Because of the consistency of the body weight differences for the selected mammalian wildlife species, the calculated NOAELs exhibit about a 15-fold range between the species of smallest body size (little brown bat) and that of the largest body size (whitetail deer). In terms of dietary intake, the range in values is much less (2-3 fold) thereby indicating that equivalent dietary levels of a chemical result in nearly equivalent doses between species because food intake is a function of metabolic rate which, in turn, is a function of body size (EPA, 1980a). However, according to EPA, the correlation is not exact because food intake also varies with moisture and caloric content of the food, and it should be noted that in laboratory feeding experiments, the test animals are usually dosed with the chemical in a dry chow. Therefore, it would be expected that the food factor for a species of wildlife would be relatively higher than that of a related laboratory species of comparable body size, resulting in a lower dietary benchmark for wildlife species as compared to that for the related laboratory species.

7. APPLICATION OF THE BENCHMARKS

As stated in Sect. 1, ecological risk assessment is a tiered process. As part of the first tier or screening assessment, toxicological benchmarks are used to identify Contaminants of Potential Concern (COPCs) and to focus future data collection. In the second tier or baseline assessment, toxicological benchmarks are one of several lines of evidence used to determine if environmental contaminant concentrations are resulting in ecological effects. In a screening assessment, general, conservative assumptions are made so that all chemicals that may be present at potentially hazardous levels in the environment are retained for future consideration. In contrast, in a baseline assessment, more specific assumptions are made so that an accurate estimate of the contaminant exposure that an individual may experience and potential effects that may result from that exposure may be made.

7.1 SCREENING ASSESSMENT

Screening assessments serve to identify those contaminants whose concentrations are sufficiently high such that they may be hazardous to wildlife. The primary emphasis of a screening assessment is to include all potential hazards while eliminating clearly insignificant hazards. To prevent any potential hazards from being overlooked, assumptions made in a screening assessment are conservative.

Questions that drive a screening assessment include: 1) Which media (water, soil, etc.) are contaminated such that they may be toxic?, 2) What chemicals are involved? (Which contaminants are COPCs)?, 3) What are the concentrations and spatial and temporal distributions of these contaminants?, and 4) What organisms are expected to be significantly exposed to the chemicals? To answer these questions, diet, water, and combined food and water (for aquatic feeding species) benchmark values are compared to the contaminant concentrations observed in the media from the site. If the concentration of a contaminant exceeds the benchmark, it should be retained as a COPC. By comparing contaminant concentrations from several locations within a site to benchmarks for several endpoint species, the spatial extent of potentially hazardous contamination, which media are contaminated, and the species potentially at risk from contamination may be identified.

In a screening assessment, it is generally assumed that wildlife species reside and therefore forage and drink exclusively from the contaminated site. That is, approximately 100% of the food and water they consume is contaminated. While this assumption simplifies the assessment, due to the mobility and the diverse diets of most wildlife, it is likely to overestimate the actual exposure experienced. It should be remembered, however, that the purpose of the screening assessment is to identify potential risks and data gaps to be filled. Once these data gaps are filled, a definitive evaluation of risk may be made as part of the baseline assessment.

In most screening assessments, because they rely on existing data, available data are likely to be restricted to contaminant concentration in abiotic media (e.g., soil and water). Contaminant concentrations in wildlife foods may need to be estimated using contaminant uptake models such as those described in Baes et al. (1984), Travis and Arms (1988), or Menzies et al. (1992).

Table 13 provides a simplified example of the use of benchmarks in a screening assessment. The purpose of the assessment in this example is to identify the contaminants and media with concentrations sufficiently high to present a hazard to a representative endpoint species (meadow vole). This information will be used to identify gaps in data needed for the baseline assessment. Data consists of the concentrations of four metals in soil and water. These data were compared to values observed at a representative background location and found to be higher. (Screening contaminant concentrations against background helps provide a regional context for the data and aids in identifying anthropogenic contamination. This is particularly important in areas where metal concentrations in native soils are naturally high.) Because dietary exposure cannot be evaluated directly from soil concentrations, metal concentrations in the voles' food (plant foliage) was estimated using plant uptake factors for foliage from Baes et al. (1984). To determine which contaminants pose a risk, a hazard quotient (HQ) was calculated, where HQ = media concentration/benchmark. If HQ is greater or equal to 1, contaminant concentrations are sufficiently high that they may produce adverse effects. Contaminants with HQs greater or equal to 1 should be retained as COPCs. In this example, while metal concentrations in water did not exceed any water benchmarks, estimated concentrations of As and Hg in plant foliage exceeded dietary benchmarks. These metals should therefore be retained as COPCs in food but not in water. Because contaminant concentrations in plant foliage were estimated, one data need for the baseline assessment consists of actual, measured concentrations in plants. In addition, the form of the metals (i.e., inorganic vs methyl mercury) should be identified so the most appropriate benchmark may be used in the baseline assessment.

7.2 BASELINE ASSESSMENT

In contrast to the screening assessment that defines the scope of the assessment, the baseline assessment uses new and existing data to evaluate the risk of leaving the site unremediated. The purposes of the baseline assessment are to determine 1) if significant ecological effects are occurring at the site, 2) the causes of these effects, 3) the source of the causal agents, and 4) the consequences of leaving the system unremediated. The baseline assessment provides the ecological basis for determining the need for remediation.

Because the baseline assessment focuses on a smaller number of contaminants and species than the screening assessment, it can provide a higher level of characterization of toxicity to the species and communities at the site. In the baseline ERA, a weight-of-evidence approach (Suter, 1993) is employed to determine if and to what degree ecological effects are occurring or may occur. The lines of evidence used in a baseline assessment consist of 1) toxicity tests using ambient media from the site, 2) biological survey data from the site, and 3) comparison of contaminant exposure experienced by endpoint species at the site to wildlife NOAELs.

Estimating the contaminant exposure experienced by wildlife at a waste site consists of summing the exposure received from each separate source. While wildlife may be exposed to contaminants through oral ingestion, inhalation, and dermal absorption, the benchmarks in this document are only applicable to the most common exposure route—oral ingestion. Exposure through inhalation and dermal absorption are special cases that must be considered independently.

The primary routes of oral exposure for terrestrial wildlife are through ingestion of food (either plant or animal) and surface water. In addition, some species may ingest soil incidentally while foraging or purposefully to meet nutrient needs. The total exposure experienced by terrestrial wildlife is represented by the sum of the exposures from each individual source. Total exposure may be represented by the following generalized equation:

$$E_{total} = E_{food} + E_{water} + E_{soil}$$

where:

E_{total} = exposure from all sources
E_{food} = exposure from food consumption
E_{water} = exposure from water consumption
E_{soil} = exposure through consumption of soil (either incidental or deliberate)

Building on the screening assessment example, Table 14 provides an example of the use of benchmarks in a baseline assessment. The purpose of the assessment in this example is to ascertain the level of exposure and risk experienced by a representative endpoint species (meadow vole). In addition to soil and water contaminant data, concentrations of As, Pb, Hg, and Se were measured in plants on which meadow voles forage. Exposure parameters for each medium were calculated according to the following equation:

$$E_{media} = \frac{\text{MCR (kg or L/d)} \times \text{ACM (mg/kg or mg/L)}}{\text{Body Weight (kg)}}$$

where E_{media} = estimated exposure (mg analyte/kg body weight/d) for each medium (e.g., food, water, and soil); MCR = medium consumption rate; and ACM = analyte concentration in media. Body weight (0.044 kg), food (0.005 kg/d) and water (0.006 L/d) consumption rates for meadow voles were obtained from Appendix B. Beyer et al. (1992) states that soil consumption by meadow voles is 2% of food consumption. Therefore, soil consumption was estimated to be 2% of 0.005 kg/d or 0.0001 kg/d. As in the screening assessment, an HQ was calculated in which total exposure was compared to the NOAEL for each contaminant. Total exposure from all sources exceeded NOAELs for both As and Se.

By comparing the exposure from each source (e.g., water, soil, diet) to the NOAEL, the relative contribution of each to the total can be determined. For example, virtually all Se exposure (98.6%) was obtained through food consumption; Se exposures from soil and water were both less then the NOAEL. In contrast, As exposure from soil and food both exceeded the NOAEL and accounted for 59% and 40% of As exposure, respectively. This information serves not only to identify contaminants that present a risk but by identifying the media that account for the majority of exposure, these data may be used to guide remediation.

In the preceding example, the species used has a small home range (< 1 ha) and a diet restricted to grassy and herbaceous plant material (Reich, 1981). Therefore, it was assumed that voles would reside and forage exclusively on the hypothetical waste site and that 100% of the food, water, and soil consumed would be contaminated. Because most wildlife are mobile and many species have varied diets, it is not likely that all food, water, or soil ingested by individuals of other wildlife endpoint species would be obtained from contaminated sources. In the case of species with large home ranges, because they may spend only a portion of their time on a contaminated site (and may receive exposure from multiple, spatially separate locations), their exposure should be represented by the proportion of food, water, or soil obtained from contaminated sources. For species with diverse diets, the contaminant concentrations in the different food types consumed is likely to differ. Dietary exposure for these species would be represented by the sum of the contaminant concentrations in each food type multiplied by the proportion of each food type in the species diet. Ideally, site-specific information on home ranges, diet composition, and use of waste sites by endpoint species should be collected. In the absence of site specific data, information to estimate exposure for selected wildlife species may be found in the Wildlife Exposure Factors Handbook (EPA, 1993a and 1993b)or in other published literature.

Table 11. Body size scaling factors

Experimental Animals		Wildlife		
Species	Body Weight[a] (bw_t, in kg)	Species	Body weight[b] (bw_w, in kg)	Scaling factor $(bw_t/bw_w)^{1/3}$
rat	0.35	short-tailed shrew	0.015	2.86
rat	0.35	white-footed mouse	0.022	2.52
rat	0.35	meadow vole	0.044	2.00
rat	0.35	cottontail rabbit	1.2	0.66
rat	0.35	mink	1.0	0.70
rat	0.35	red fox	4.5	0.43
rat	0.35	whitetail deer	56.5	0.18
mouse	0.03	short-tailed shrew	0.015	1.26
mouse	0.03	white-footed mouse	0.022	1.11
mouse	0.03	meadow vole	0.004	0.88
mouse	0.03	cottontail rabbit	1.2	0.29
mouse	0.03	mink	1.0	0.31
mouse	0.03	red fox	4.5	0.19
mouse	0.03	whitetail deer	56.5	0.08

[a] Standard reference values used by EPA.
[b] From Appendix B.

Table 12. Toxicological benchmarks for selected avian and mammalian wildlife species

Contaminant and Form	Test Species	Test Species NOAEL[a] (mg/kg • d)	Endpoint Species[b]	Estimated Wildlife NOAEL[c] (mg/kg • d)	Toxicological Benchmarks		
					Diet[d] (mg/kg)	Water[e] (mg/L)	Aquatic Feeding Species[f] (mg/L)
Acetone	Rat	10	Short-tailed Shrew	28.277	47.128	128.531	
			Little Brown Bat	35.545	106.634	222.153	
			White-footed Mouse	24.920	161.245	83.066	
			Meadow Vole	19.825	174.456	145.380	
			Cottontail Rabbit	6.659	33.717	68.887	
			Mink	7.072	51.620	71.434	4.64e+01
			Red Fox	4.305	43.051	50.981	
			Whitetail Deer	1.868	60.656	28.525	
Aldrin	Rat	0.2	Short-tailed Shrew	0.566	0.943	2.571	
			Little Brown Bat	0.711	2.133	4.443	
			White-footed Mouse	0.498	3.225	1.661	
			Meadow Vole	0.396	3.489	2.908	
			Cottontail Rabbit	0.133	0.674	1.378	
			Mink	0.141	1.032	1.429	
			Red Fox	0.086	0.861	1.020	
			Whitetail Deer	0.037	1.213	0.571	

Table 12. (continued)

Contaminant and Form	Test Species	Test Species NOAEL[a] (mg/kg • d)	Endpoint Species[b]	Estimated Wildlife NOAEL[c] (mg/kg • d)	Toxicological Benchmarks		
					Diet[d] (mg/kg)	Water[e] (mg/L)	Aquatic Feeding Species[f] (mg/L)
Aluminum	Mouse	1.93	Short-tailed Shrew	2.426	4.043	11.027	
$AlCl_3$			Little Brown Bat	3.050	9.149	19.060	
			White-footed Mouse	2.138	13.834	7.127	
			Meadow Vole	1.701	14.967	12.473	
			Cottontail Rabbit	0.571	2.893	5.910	
			Mink	0.607	4.429	6.129	1.991e-02
			Red Fox	0.369	3.694	4.374	
			Whitetail Deer	0.160	5.204	2.447	
Aluminum	Ringed Dove	111.4	American Robin	140.331	116.188	1019.383	
Al2(SO4)2			American Woodcock	102.753	135.634	1017.256	
			Wild Turkey	33.711	1123.692	1029.065	
			Belted Kingfisher	113.112	223.208	1046.288	9.65e-01
			Great Blue Heron	45.167	257.022	1020.316	1.11e+00
			Barred Owl	67.201	1029.553	1025.172	
			Barn Owl	77.469	577.606	1031.440	
			Cooper's Hawk	79.009	1020.150	1020.150	
			Red-tailed Hawk	57.901	71.645	1018.700	

Table 12. (continued)

Contaminant and Form	Test Species	Test Species NOAEL[a] (mg/kg • d)	Endpoint Species[b]	Estimated Wildlife NOAEL[c] (mg/kg • d)	Toxicological Benchmarks		
					Diet[d] (mg/kg)	Water[e] (mg/L)	Aquatic Feeding Species[f] (mg/L)
Antimony	Mouse	0.125	Short-tailed Shrew	0.157	0.262	0.714	
Antimony Potassium Tartrate			Little Brown Bat	0.198	0.593	1.234	
			White-footed Mouse	0.138	0.896	0.462	
			Meadow Vole	0.110	0.969	0.808	
			Cottontail Rabbit	0.037	0.187	0.383	
			Mink	0.039	0.287	0.397	1.67e-01
			Red Fox	0.024	0.239	0.283	
			Whitetail Deer	0.010	0.337	0.159	
Aroclor 1016	Mink	1.37	Short-tailed Shrew	5.478	9.130	24.899	
			Little Brown Bat	6.886	20.657	43.036	
			White-footed Mouse	4.827	31.237	16.092	
			Meadow Vole	3.840	33.796	28.163	
			Cottontail Rabbit	1.290	6.532	13.345	
			Mink	1.370	10.000	13.838	1.26e-04
			Red Fox	0.834	8.340	9.876	
			Whitetail Deer	0.362	11.750	5.526	

Table 12. (continued)

Contaminant and Form	Test Species	Test Species NOAEL[a] (mg/kg • d)	Endpoint Species[b]	Estimated Wildlife NOAEL[c] (mg/kg • d)	Toxicological Benchmarks		
					Diet[d] (mg/kg)	Water[e] (mg/L)	Aquatic Feeding Species[f] (mg/L)
Aroclor 1242	Mink	0.0685	Short-tailed Shrew	0.274	0.456	1.245	
			Little Brown Bat	0.344	1.033	2.152	
			White-footed Mouse	0.241	1.562	0.805	
			Meadow Vole	0.192	1.690	1.408	
			Cottontail Rabbit	0.065	0.327	0.667	
			Mink	0.069	0.500	0.692	6.28e-06
			Red Fox	0.042	0.417	0.494	
			Whitetail Deer	0.018	0.587	0.276	
Aroclor 1242	Screech Owl	0.41	American Robin	0.544	0.450	3.949	
			American Woodcock	0.398	0.525	3.941	
			Wild Turkey	0.131	4.353	3.986	
			Belted Kingfisher	0.438	0.865	4.053	1.09e-05
			Great Blue Heron	0.175	0.996	3.952	1.25e-05
			Barred Owl	0.260	3.988	3.971	
			Barn Owl	0.300	2.237	3.995	
			Cooper's Hawk	0.306	3.952	3.952	
			Red-tailed Hawk	0.224	0.278	3.946	

Table 12. (continued)

Contaminant and Form	Test Species	Test Species NOAEL[a] (mg/kg · d)	Endpoint Species[b]	Estimated Wildlife NOAEL[c] (mg/kg · d)	Toxicological Benchmarks		
					Diet[d] (mg/kg)	Water[e] (mg/L)	Aquatic Feeding Species[f] (mg/L)
Aroclor 1248	Rhesus Monkey	0.01	Short-tailed Shrew	0.068	0.113	0.309	
			Little Brown Bat	0.085	0.256	0.534	
			White-footed Mouse	0.060	0.388	0.200	
			Meadow Vole	0.048	0.420	0.350	
			Cottontail Rabbit	0.016	0.081	0.166	
			Mink	0.017	0.124	0.172	1.41e-07
			Red Fox	0.010	0.104	0.123	
			Whitetail Deer	0.004	0.146	0.069	
Aroclor 1254	White-footed mouse	0.135	Short-tailed Shrew	0.148	0.247	0.675	
			Little Brown Bat	0.187	0.560	1.166	
			White-footed Mouse	0.131	0.846	0.436	
			Meadow Vole	0.104	0.916	0.763	
			Cottontail Rabbit	0.035	0.177	0.362	
			Whitetail Deer	0.010	0.319	0.150	
Aroclor 1254	Mink	0.137	Mink	0.137	1	1.384	4.33e-07
			Red Fox	0.083	0.834	0.988	

Table 12. (continued)

Contaminant and Form	Test Species	Test Species NOAEL[a] (mg/kg • d)	Endpoint Species[b]	Estimated Wildlife NOAEL[c] (mg/kg • d)	Toxicological Benchmarks		
					Diet[d] (mg/kg)	Water[e] (mg/L)	Aquatic Feeding Species[f] (mg/L)
Aroclor 1254	Ring-necked Pheasant	0.18	American Robin	0.420	0.347	3.047	
			American Woodcock	0.307	0.405	3.041	
			Wild Turkey	0.101	3.359	3.076	
			Belted Kingfisher	0.338	0.667	3.128	2.89e-07
			Great Blue Heron	0.135	0.768	3.050	3.33e-07
			Barred Owl	0.201	3.078	3.065	
			Barn Owl	0.232	1.727	3.083	
			Cooper's Hawk	0.236	3.050	3.050	
			Red-tailed Hawk	0.173	0.214	3.045	
Arsenic	Mouse	0.126	Short-tailed Shrew	0.158	0.264	0.720	
Arsenite			Little Brown Bat	0.199	0.597	1.244	
			White-footed Mouse	0.140	0.903	0.465	
			Meadow Vole	0.111	0.977	0.814	
			Cottontail Rabbit	0.037	0.189	0.386	
			Mink	0.040	0.289	0.400	1.63e-02
			Red Fox	0.024	0.241	0.286	
			Whitetail Deer	0.010	0.340	0.160	

Table 12. (continued)

Contaminant and Form	Test Species	Test Species NOAEL[a] (mg/kg · d)	Endpoint Species[b]	Estimated Wildlife NOAEL[c] (mg/kg · d)	Toxicological Benchmarks		
					Diet[d] (mg/kg)	Water[e] (mg/L)	Aquatic Feeding Species[f] (mg/L)
Arsenic	Mallard Duck	5.135	American Robin	11.967	9.908	86.933	
Sodium Arsenite			American Woodcock	8.763	11.567	86.751	
			Wild Turkey	2.875	95.828	87.758	
			Belted Kingfisher	9.646	19.035	89.227	1.11e+00
			Great Blue Heron	3.852	21.919	87.013	1.27e+00
			Barred Owl	5.731	87.800	87.426	
			Barn Owl	6.607	49.258	87.961	
			Cooper's Hawk	6.738	86.999	86.999	
			Red-tailed Hawk	4.938	6.110	86.875	
Arsenic	Brown-headed Cowbird	2.46	American Robin	2.119	1.755	15.394	
Paris Green: Copper Acetoarsenite			American Woodcock	1.552	2.048	15.362	
			Wild Turkey	0.509	16.968	15.539	
			Belted Kingfisher	1.708	3.371	15.800	1.96e-01
			Great Blue Heron	0.682	3.881	15.408	2.25e-01
			Barred Owl	1.015	15.547	15.481	
			Barn Owl	1.170	8.722	15.576	
			Cooper's Hawk	1.193	15.405	15.405	
			Red-tailed Hawk	0.874	1.082	15.383	

Table 12. (continued)

Contaminant and Form	Test Species	Test Species NOAEL[a] (mg/kg • d)	Endpoint Species[b]	Estimated Wildlife NOAEL[c] (mg/kg • d)	Toxicological Benchmarks		
					Diet[d] (mg/kg)	Water[e] (mg/L)	Aquatic Feeding Species[f] (mg/L)
Barium	Rat	5.06	Short-tailed Shrew	15.372	25.621	69.874	
Braium Chloride			Little Brown Bat	19.323	57.970	120.771	
			White-footed Mouse	13.547	87.659	45.158	
			Meadow Vole	10.777	94.841	79.034	
			Cottontail Rabbit	3.620	18.330	37.450	
			Mink	3.845	28.063	38.834	
			Red Fox	2.340	23.404	27.715	
			Whitetail Deer	1.015	32.974	15.507	
Barium	Chicken	20.86	American Robin	24.215	20.049	175.904	
Barium Hydroxide			American Woodcock	17.731	23.405	175.537	
			Wild Turkey	5.817	193.901	177.572	
			Belted Kingfisher	19.518	38.516	180.546	
			Great Blue Heron	7.794	44.352	176.068	
			Barred Owl	11.596	177.658	176.902	
			Barn Owl	13.368	99.671	177.984	
			Cooper's Hawk	13.634	176.038	176.038	
			Red-tailed Hawk	9.991	12.363	175.785	

Table 12. (continued)

Contaminant and Form	Test Species	Test Species NOAEL[a] (mg/kg • d)	Endpoint Species[b]	Estimated Wildlife NOAEL[c] (mg/kg • d)	Toxicological Benchmarks		
					Diet[d] (mg/kg)	Water[e] (mg/L)	Aquatic Feeding Species[f] (mg/L)
Benzene	Mouse	26.36	Short-tailed Shrew	33.135	55.225	150.613	
			Little Brown Bat	41.651	124.953	260.318	
			White-footed Mouse	29.201	188.946	97.336	
			Meadow Vole	23.230	204.426	170.355	
			Cottontail Rabbit	7.803	39.509	80.722	
			Mink	8.287	60.489	83.708	2.40e+00
			Red Fox	5.045	50.448	59.741	
			Whitetail Deer	2.189	71.077	33.426	
beta-BHC	Rat	0.4	Short-tailed Shrew	1.131	1.885	5.141	
			Little Brown Bat	1.422	4.265	8.886	
			White-footed Mouse	0.997	6.450	3.323	
			Meadow Vole	0.793	6.978	5.815	
			Cottontail Rabbit	0.266	1.349	2.755	
			Mink	0.283	2.065	2.857	
			Red Fox	0.172	1.722	2.039	
			Whitetail Deer	0.075	2.426	1.141	

Table 12. (continued)

Contaminant and Form	Test Species	Test Species NOAEL[a] (mg/kg • d)	Endpoint Species[b]	Estimated Wildlife NOAEL[c] (mg/kg • d)	Toxicological Benchmarks		
					Diet[d] (mg/kg)	Water[e] (mg/L)	Aquatic Feeding Species[f] (mg/L)
BHC-mixed isomers	Rat	1.6	Short-tailed Shrew	4.524	7.541	20.565	
			Little Brown Bat	5.687	17.061	35.545	
			White-footed Mouse	3.987	25.799	13.291	
			Meadow Vole	3.172	27.913	23.261	
			Cottontail Rabbit	1.065	5.395	11.022	
			Whitetail Deer	0.299	9.705	4.564	
BHC-mixed isomers	Mink	0.0137	Mink	0.014	0.100	0.138	4.23e-06
			Red Fox	0.008	0.083	0.099	
BHC-mixed isomers	Japanese Quail	0.563	American Robin	0.702	0.581	5.096	
			American Woodcock	0.514	0.678	5.086	
			Wild Turkey	0.169	5.618	5.145	
			Belted Kingfisher	0.566	1.116	5.231	4.72e-05
			Great Blue Heron	0.226	1.285	5.101	5.43e-05
			Barred Owl	0.336	5.147	5.125	
			Barn Owl	0.387	2.888	5.157	
			Cooper's Hawk	0.395	5.100	5.100	
			Red-tailed Hawk	0.289	0.358	5.093	

Table 12. (continued)

Contaminant and Form	Test Species	Test Species NOAEL[a] (mg/kg • d)	Endpoint Species[b]	Estimated Wildlife NOAEL[c] (mg/kg • d)	Toxicological Benchmarks		
					Diet[d] (mg/kg)	Water[e] (mg/L)	Aquatic Feeding Species[f] (mg/L)
Benzo(a)pyrene	Mouse	1	Short-tailed Shrew	1.257	2.095	5.714	
			Little Brown Bat	1.580	4.740	9.876	
			White-footed Mouse	1.108	7.168	3.693	
			Meadow Vole	0.881	7.755	6.463	
			Cottontail Rabbit	0.296	1.499	3.062	
			Mink	0.314	2.295	3.176	3.60e-06
			Red Fox	0.191	1.914	2.266	
			Whitetail Deer	0.083	2.696	1.268	
Beryllium	Rat	0.66	Short-tailed Shrew	1.866	3.110	8.483	
Beryllium Sulfate			Little Brown Bat	2.346	7.038	14.662	
			White-footed Mouse	1.645	10.642	5.482	
			Meadow Vole	1.308	11.514	9.595	
			Cottontail Rabbit	0.440	2.225	4.547	
			Mink	0.467	3.407	4.715	1.73e-01
			Red Fox	0.284	2.841	3.365	
			Whitetail Deer	0.123	4.003	1.883	

Table 12. (continued)

Contaminant and Form	Test Species	Test Species NOAEL[a] (mg/kg • d)	Endpoint Species[b]	Estimated Wildlife NOAEL[c] (mg/kg • d)	Toxicological Benchmarks		
					Diet[d] (mg/kg)	Water[e] (mg/L)	Aquatic Feeding Species[f] (mg/L)
Bis(2-ethylhexyl) phthalate	mouse	18.33	Short-tailed Shrew	23.041	38.402	104.732	
			Little Brown Bat	28.963	86.889	181.018	
			White-footed Mouse	20.305	131.388	67.685	
			Meadow Vole	16.154	142.152	118.460	
			Cottontail Rabbit	5.426	27.474	56.132	
			Mink	5.763	42.063	58.208	3.74e-03
			Red Fox	3.508	35.080	41.542	
			Whitetail Deer	1.522	49.425	23.243	
Bis(2-ethylhexyl) phthalate	ringed dove	1.11	American Robin	1.398	1.158	10.157	
			American Woodcock	1.024	1.351	10.136	
			Wild Turkey	0.336	11.197	10.254	
			Belted Kingfisher	1.127	2.224	10.425	1.98e-04
			Great Blue Heron	0.450	2.561	10.167	2.27e-04
			Barred Owl	0.670	10.259	10.215	
			Barn Owl	0.772	5.755	10.277	
			Cooper's Hawk	0.787	10.165	10.165	
			Red-tailed Hawk	0.577	0.714	10.150	

Table 12. (continued)

Contaminant and Form	Test Species	Test Species NOAEL[a] (mg/kg • d)	Endpoint Species[b]	Estimated Wildlife NOAEL[c] (mg/kg • d)	Toxicological Benchmarks		
					Diet[d] (mg/kg)	Water[e] (mg/L)	Aquatic Feeding Species[f] (mg/L)
Cadmium	mouse	0.1913	Short-tailed Shrew	0.240	0.401	1.093	
Soluble salt			Little Brown Bat	0.302	0.907	1.889	
			White-footed Mouse	0.212	1.371	0.706	
			Meadow Vole	0.169	1.484	1.236	
			Cottontail Rabbit	0.057	0.287	0.586	
			Mink	0.060	0.439	0.607	3.54e-05
			Red Fox	0.037	0.366	0.434	
			Whitetail Deer	0.016	0.516	0.243	
Cadmium	mallard duck	1.45	American Robin	3.542	2.932	25.728	
Cadmium Chloride			American Woodcock	2.593	3.423	25.675	
			Wild Turkey	0.851	28.361	25.973	
			Belted Kingfisher	2.855	5.634	26.407	4.54e-04
			Great Blue Heron	1.140	6.487	25.752	5.23e-04
			Barred Owl	1.696	25.985	25.874	
			Barn Owl	1.955	14.578	26.033	
			Cooper's Hawk	1.994	25.748	25.748	
			Red-tailed Hawk	1.461	1.808	25.711	

Table 12. (continued)

Contaminant and Form	Test Species	Test Species NOAEL[a] (mg/kg · d)	Endpoint Species[b]	Estimated Wildlife NOAEL[c] (mg/kg · d)	Toxicological Benchmarks		
					Diet[d] (mg/kg)	Water[e] (mg/L)	Aquatic Feeding Species[f] (mg/L)
Carbon Tetrachloride	Rat	16	Short-tailed Shrew	45.243	75.405	205.650	
			Little Brown Bat	56.871	170.614	355.445	
			White-footed Mouse	39.872	257.992	132.905	
			Meadow Vole	31.719	279.129	232.607	
			Cottontail Rabbit	10.655	53.947	110.220	
			Mink	11.315	82.593	114.295	9.83e-01
			Red Fox	6.888	68.882	81.570	
			Whitetail Deer	2.989	97.050	45.640	
Chlordane	mouse	4.58	Short-tailed Shrew	5.757	9.595	26.169	
			Little Brown Bat	7.237	21.710	45.230	
			White-footed Mouse	5.074	32.829	16.912	
			Meadow Vole	4.036	35.519	29.599	
			Cottontail Rabbit	1.356	6.865	14.025	
			Mink	1.440	10.510	14.544	1.86e-04
			Red Fox	0.877	8.765	10.380	
			Whitetail Deer	0.380	12.349	5.808	

Table 12. (continued)

Contaminant and Form	Test Species	Test Species NOAEL[a] (mg/kg • d)	Endpoint Species[b]	Estimated Wildlife NOAEL[c] (mg/kg • d)	Toxicological Benchmarks		
					Diet[d] (mg/kg)	Water[e] (mg/L)	Aquatic Feeding Species[f] (mg/L)
Chlordane	red-winged blackbird	2.14	American Robin	2.013	1.667	14.625	
			American Woodcock	1.474	1.946	14.594	
			Wild Turkey	0.484	16.121	14.764	
			Belted Kingfisher	1.623	3.202	15.011	5.68e-05
			Great Blue Heron	0.648	3.687	14.638	6.54e-05
			Barred Owl	0.964	14.771	14.708	
			Barn Owl	1.111	8.287	14.798	
			Cooper's Hawk	1.134	14.636	14.636	
			Red-tailed Hawk	0.831	1.028	14.615	
Chlordecone (Kepone)	Rat	0.08	Short-tailed Shrew	0.226	0.377	1.028	
			Little Brown Bat	0.284	0.853	1.777	
			White-footed Mouse	0.199	1.290	0.665	
			Meadow Vole	0.159	1.396	1.163	
			Cottontail Rabbit	0.053	0.270	0.551	
			Mink	0.057	0.413	0.572	
			Red Fox	0.034	0.344	0.408	
			Whitetail Deer	0.015	0.485	0.228	

Table 12. (continued)

Contaminant and Form	Test Species	Test Species NOAEL[a] (mg/kg • d)	Endpoint Species[b]	Estimated Wildlife NOAEL[c] (mg/kg • d)	Toxicological Benchmarks		
					Diet[d] (mg/kg)	Water[e] (mg/L)	Aquatic Feeding Species[f] (mg/L)
Chloroform	Rat	15	Short-tailed Shrew	42.415	70.692	192.797	
			Little Brown Bat	53.317	159.950	333.230	
			White-footed Mouse	37.380	241.868	124.599	
			Meadow Vole	29.737	261.683	218.070	
			Cottontail Rabbit	9.989	50.575	103.331	
			Mink	10.608	77.431	107.152	4.03e+00
			Red Fox	6.458	64.577	76.472	
			Whitetail Deer	2.802	90.984	42.787	
Chromium	Rat	2737	Short-tailed Shrew	7739.388	12898.979	35179.034	
Cr+3 as Cr2O3			Little Brown Bat	9728.530	29185.589	60803.310	
			White-footed Mouse	6820.522	44132.789	22735.073	
			Meadow Vole	5425.966	47748.498	39790.415	
			Cottontail Rabbit	1822.596	9228.333	18854.438	
			Mink	1935.606	14128.514	19551.580	
			Red Fox	1178.306	11783.059	13953.622	
			Whitetail Deer	511.272	16601.635	7807.256	

Table 12. (continued)

Contaminant and Form	Test Species	Test Species NOAEL[a] (mg/kg • d)	Endpoint Species[b]	Estimated Wildlife NOAEL[c] (mg/kg • d)	Toxicological Benchmarks		
					Diet[d] (mg/kg)	Water[e] (mg/L)	Aquatic Feeding Species[f] (mg/L)
Chromium	black duck	1	American Robin	2.509	2.077	18.223	
Cr+3 as CrK(SO4)2			American Woodcock	1.837	2.425	18.185	
			Wild Turkey	0.603	20.088	18.396	
			Belted Kingfisher	2.022	3.990	18.704	
			Great Blue Heron	0.807	4.595	18.240	
			Barred Owl	1.201	18.405	18.327	
			Barn Owl	1.385	10.326	18.439	
			Cooper's Hawk	1.412	18.237	18.237	
			Red-tailed Hawk	1.035	1.281	18.211	
Chromium	Rat	3.28	Short-tailed Shrew	9.275	15.458	42.158	
Cr+6 as K2Cr2O4			Little Brown Bat	11.659	34.976	72.866	
			White-footed Mouse	8.174	52.888	27.246	
			Meadow Vole	6.502	57.221	47.685	
			Cottontail Rabbit	2.184	11.059	22.595	
			Mink	2.320	16.932	23.431	4.55e+00
			Red Fox	1.412	14.121	16.722	
			Whitetail Deer	0.613	19.895	9.356	

Table 12. (continued)

Contaminant and Form	Test Species	Test Species NOAEL[a] (mg/kg • d)	Endpoint Species[b]	Estimated Wildlife NOAEL[c] (mg/kg • d)	Toxicological Benchmarks		
					Diet[d] (mg/kg)	Water[e] (mg/L)	Aquatic Feeding Species[f] (mg/L)
Copper	Mink	11.71	Short-tailed Shrew	46.822	78.036	212.826	
Copper Sulfate			Little Brown Bat	58.855	176.566	367.846	
			White-footed Mouse	41.263	266.994	137.542	
			Meadow Vole	32.826	288.868	240.724	
			Cottontail Rabbit	11.026	55.829	114.065	
			Mink	11.710	85.474	118.283	2.94e-01
			Red Fox	7.128	71.285	84.416	
			Whitetail Deer	3.093	100.432	47.230	
Copper	Chicken	33.21	American Robin	62.924	52.098	457.089	
Copper Oxide			American Woodcock	46.074	60.818	456.135	
			Wild Turkey	15.116	503.851	461.421	
			Belted Kingfisher	50.719	100.085	469.151	3.45e-01
			Great Blue Heron	20.253	115.248	457.506	3.97e-01
			Barred Owl	30.132	461.644	459.680	
			Barn Owl	34.737	258.997	462.494	
			Cooper's Hawk	35.428	457.435	457.435	
			Red-tailed Hawk	25.963	32.125	456.779	

Table 12. (continued)

Contaminant and Form	Test Species	Test Species NOAEL[a] (mg/kg • d)	Endpoint Species[b]	Estimated Wildlife NOAEL[c] (mg/kg • d)	Toxicological Benchmarks		
					Diet[d] (mg/kg)	Water[e] (mg/L)	Aquatic Feeding Species[f] (mg/L)
o-Cresol	mink	216.2	Short-tailed Shrew	864.461	1440.768	3929.366	
			Little Brown Bat	1086.639	3259.916	6791.491	
			White-footed Mouse	761.826	4929.463	2539.420	
			Meadow Vole	606.060	5333.332	4444.444	
			Cottontail Rabbit	203.576	1030.765	2105.959	
			Mink	216.200	1578.102	2183.838	8.49e+01
			Red Fox	131.612	1316.118	1558.560	
			Whitetail Deer	57.105	1854.269	872.007	
Cyanide	Rat	6.87	Short-tailed Shrew	17.897	29.828	81.350	
			Little Brown Bat	22.497	67.490	140.605	
			White-footed Mouse	15.772	102.055	52.574	
			Meadow Vole	12.547	110.416	92.014	
			Cottontail Rabbit	4.215	21.340	43.599	
			Mink	4.476	32.672	45.212	4.52e+01
			Red Fox	2.725	27.248	32.267	
			Whitetail Deer	1.182	38.389	18.053	

Table 12. (continued)

Contaminant and Form	Test Species	Test Species NOAEL[a] (mg/kg • d)	Endpoint Species[b]	Estimated Wildlife NOAEL[c] (mg/kg • d)	Toxicological Benchmarks		
					Diet[d] (mg/kg)	Water[e] (mg/L)	Aquatic Feeding Species[f] (mg/L)
DDT (and metabolites)	Rat	0.8	Short-tailed Shrew	2.262	3.770	10.283	
			Little Brown Bat	2.844	8.531	17.772	
			White-footed Mouse	1.994	12.900	6.645	
			Meadow Vole	1.586	13.956	11.630	
			Cottontail Rabbit	0.533	2.697	5.511	
			Mink	0.566	4.130	5.715	2.64e-06
			Red Fox	0.344	3.444	4.079	
			Whitetail Deer	0.149	4.853	2.282	
DDT (and metabolites)	Brown Pelican	0.00028	American Robin	0.00099	0.00082	0.00719	
			American Woodcock	0.00072	0.00095	0.00713	
			Wild Turkey	0.00024	0.008	0.00733	
			Belted Kingfisher	0.0008	0.00158	0.0074	1.01e-09
			Great Blue Heron	0.00032	0.00182	0.00723	1.16e-09
			Barred Owl	0.00047	0.0072	0.00717	
			Barn Owl	0.00054	0.00403	0.00719	
			Cooper's Hawk	0.00056	0.00723	0.00723	
			Red-tailed Hawk	0.00041	0.00051	0.00721	

Table 12. (continued)

Contaminant and Form	Test Species	Test Species NOAEL[a] (mg/kg • d)	Endpoint Species[b]	Estimated Wildlife NOAEL[c] (mg/kg • d)	Toxicological Benchmarks		
					Diet[d] (mg/kg)	Water[e] (mg/L)	Aquatic Feeding Species[f] (mg/L)
1,2-Dichloroethane	mouse	50	Short-tailed Shrew	66.131	110.218	300.593	
			Little Brown Bat	83.127	249.381	519.544	
			White-footed Mouse	58.279	377.099	194.263	
			Meadow Vole	46.363	407.994	339.995	
			Cottontail Rabbit	15.574	78.853	161.105	
			Mink	16.539	120.723	167.061	1.41e+01
			Red Fox	10.068	100.680	119.226	
			Whitetail Deer	4.369	141.851	66.708	
1,2-Dichloroethane	chicken	17.2	American Robin	46.811	38.757	340.041	
			American Woodcock	34.276	45.244	339.331	
			Wild Turkey	11.245	374.834	343.269	
			Belted Kingfisher	37.731	74.456	349.015	9.24e+00
			Great Blue Heron	15.067	85.737	340.353	1.06e+01
			Barred Owl	22.416	343.431	341.970	
			Barn Owl	25.842	192.675	344.063	
			Cooper's Hawk	26.356	340.299	340.299	
			Red-tailed Hawk	19.314	23.899	339.813	

Table 12. (continued)

Contaminant and Form	Test Species	Test Species NOAEL[a] (mg/kg • d)	Endpoint Species[b]	Estimated Wildlife NOAEL[c] (mg/kg • d)	Toxicological Benchmarks		
					Diet[d] (mg/kg)	Water[e] (mg/L)	Aquatic Feeding Species[f] (mg/L)
1,1-Dichloroethylene	Rat	30	Short-tailed Shrew	84.831	141.385	385.594	
			Little Brown Bat	106.634	319.901	666.459	
			White-footed Mouse	74.759	483.735	249.197	
			Meadow Vole	59.474	523.367	436.139	
			Cottontail Rabbit	19.977	101.151	206.662	
			Whitetail Deer	5.604	181.969	85.575	
1,1-Dichloroethylene	beagle dog	2.5	Mink	5.345	39.014	53.989	1.55e+00
			Red Fox	3.254	32.537	38.531	
1,2-Dichloroethylene	mouse	45.2	Short-tailed Shrew	56.817	94.695	258.258	
			Little Brown Bat	71.420	214.259	446.373	
			White-footed Mouse	50.071	323.990	166.904	
			Meadow Vole	39.833	350.534	292.112	
			Cottontail Rabbit	13.380	67.747	138.415	
			Mink	14.210	103.722	143.535	6.49e+00
			Red Fox	8.650	86.504	102.439	
			Whitetail Deer	3.753	121.878	57.316	

Table 12. (continued)

Contaminant and Form	Test Species	Test Species NOAEL[a] (mg/kg • d)	Endpoint Species[b]	Estimated Wildlife NOAEL[c] (mg/kg • d)	Toxicological Benchmarks		
					Diet[d] (mg/kg)	Water[e] (mg/L)	Aquatic Feeding Species[f] (mg/L)
Dieldrin	Rat	0.02	Short-tailed Shrew	0.057	0.094	0.257	
			Little Brown Bat	0.071	0.213	0.444	
			White-footed Mouse	0.050	0.322	0.166	
			Meadow Vole	0.040	0.349	0.291	
			Cottontail Rabbit	0.013	0.067	0.138	
			Mink	0.014	0.103	0.143	4.61e-05
			Red Fox	0.009	0.086	0.102	
			Whitetail Deer	0.004	0.121	0.057	
Dieldrin	Barn Owl	0.077	American Robin	0.139	0.115	1.013	
			American Woodcock	0.102	0.135	1.011	
			Wild Turkey	0.034	1.117	1.023	
			Belted Kingfisher	0.112	0.222	1.040	9.92e-05
			Great Blue Heron	0.045	0.255	1.014	1.14e-04
			Barred Owl	0.067	1.023	1.019	
			Barn Owl	0.077	0.574	1.025	
			Cooper's Hawk	0.079	1.014	1.014	
			Red-tailed Hawk	0.058	0.071	1.013	

Table 12. (continued)

Contaminant and Form	Test Species	Test Species NOAEL[a] (mg/kg • d)	Endpoint Species[b]	Estimated Wildlife NOAEL[c] (mg/kg • d)	Toxicological Benchmarks		
					Diet[d] (mg/kg)	Water[e] (mg/L)	Aquatic Feeding Species[f] (mg/L)
Diethylphthalate	mouse	4583	Short-tailed Shrew	5760.877	9601.461	26185.804	
			Little Brown Bat	7241.507	21724.520	45259.417	
			White-footed Mouse	5076.910	32850.594	16923.033	
			Meadow Vole	4038.860	35541.972	29618.310	
			Cottontail Rabbit	1356.660	6869.163	14034.410	
			Mink	1440.804	10516.814	14553.571	2.33e+02
			Red Fox	877.095	8770.945	10386.646	
			Whitetail Deer	380.572	12357.664	5811.442	
Di-n-butyl phthalate	Mouse	550	Short-tailed Shrew	691.356	1152.259	3142.525	
			Little Brown Bat	869.044	2607.132	5431.525	
			White-footed Mouse	609.274	3942.358	2030.912	
			Meadow Vole	484.699	4265.347	3554.456	
			Cottontail Rabbit	162.811	824.359	1684.252	
			Mink	172.909	1262.109	1746.556	1.41e+00
			Red Fox	105.259	1052.590	1246.488	
			Whitetail Deer	45.672	1483.028	697.424	

Table 12. (continued)

Contaminant and Form	Test Species	Test Species NOAEL[a] (mg/kg • d)	Endpoint Species[b]	Estimated Wildlife NOAEL[c] (mg/kg • d)	Toxicological Benchmarks		
					Diet[d] (mg/kg)	Water[e] (mg/L)	Aquatic Feeding Species[f] (mg/L)
Di-n-butyl phthalate	Ring dove	0.111	American Robin	0.140	0.116	1.016	
			American Woodcock	0.102	0.135	1.014	
			Wild Turkey	0.034	1.120	1.025	
			Belted Kingfisher	0.113	0.222	1.043	2.49e-04
			Great Blue Heron	0.045	0.256	1.017	2.87e-04
			Barred Owl	0.067	1.026	1.022	
			Barn Owl	0.077	0.576	1.028	
			Cooper's Hawk	0.079	1.017	1.017	
			Red-tailed Hawk	0.058	0.071	1.015	
Di-n-hexyl phthalate	mouse	55	Short-tailed Shrew	69.136	115.226	314.253	
			Little Brown Bat	86.904	260.713	543.153	
			White-footed Mouse	60.927	394.236	203.091	
			Meadow Vole	48.470	426.535	355.446	
			Cottontail Rabbit	16.281	82.436	168.425	
			Mink	17.291	126.211	174.656	
			Red Fox	10.526	105.259	124.649	
			Whitetail Deer	4.567	148.303	69.742	

Table 12. (continued)

Contaminant and Form	Test Species	Test Species NOAEL[a] (mg/kg • d)	Endpoint Species[b]	Estimated Wildlife NOAEL[c] (mg/kg • d)	Toxicological Benchmarks Diet[d] (mg/kg)	Toxicological Benchmarks Water[e] (mg/L)	Toxicological Benchmarks Aquatic Feeding Species[f] (mg/L)
1,4-Dioxane	Rat	0.5	Short-tailed Shrew	1.414	2.356	6.427	
			Little Brown Bat	1.777	5.332	11.108	
			White-footed Mouse	1.246	8.062	4.153	
			Meadow Vole	0.991	8.723	7.269	
			Cottontail Rabbit	0.333	1.686	3.444	
			Mink	0.354	2.581	3.572	2.37e+00
			Red Fox	0.215	2.153	2.549	
			Whitetail Deer	0.093	3.033	1.426	
Endosulfan	Rat	0.15	Short-tailed Shrew	0.424	0.707	1.928	
			Little Brown Bat	0.533	1.600	3.332	
			White-footed Mouse	0.374	2.419	1.246	
			Meadow Vole	0.297	2.617	2.181	
			Cottontail Rabbit	0.100	0.506	1.033	
			Mink	0.106	0.774	1.072	
			Red Fox	0.065	0.646	0.765	
			Whitetail Deer	0.028	0.910	0.428	

Table 12. (continued)

Contaminant and Form	Test Species	Test Species NOAEL[a] (mg/kg • d)	Endpoint Species[b]	Estimated Wildlife NOAEL[c] (mg/kg • d)	Toxicological Benchmarks		
					Diet[d] (mg/kg)	Water[e] (mg/L)	Aquatic Feeding Species[f] (mg/L)
Endosulfan	Gray Partridge	10	American Robin	17.224	14.261	125.119	
			American Woodcock	12.612	16.648	124.858	
			Wild Turkey	4.138	137.920	126.306	
			Belted Kingfisher	13.883	27.396	128.421	
			Great Blue Heron	5.544	31.547	125.233	
			Barred Owl	8.248	126.367	125.829	
			Barn Owl	9.509	70.895	126.599	
			Cooper's Hawk	9.698	125.213	125.213	
			Red-tailed Hawk	7.107	8.794	125.035	
Endrin	Mouse	0.092	Short-tailed Shrew	0.116	0.193	0.526	
			Little Brown Bat	0.145	0.436	0.909	
			White-footed Mouse	0.102	0.659	0.340	
			Meadow Vole	0.081	0.714	0.595	
			Cottontail Rabbit	0.027	0.138	0.282	
			Mink	0.029	0.211	0.292	9.44e-05
			Red Fox	0.018	0.176	0.209	
			Whitetail Deer	0.008	0.248	0.117	

Table 12. (continued)

Contaminant and Form	Test Species	Test Species NOAEL[a] (mg/kg • d)	Endpoint Species[b]	Estimated Wildlife NOAEL[c] (mg/kg • d)	Toxicological Benchmarks		
					Diet[d] (mg/kg)	Water[e] (mg/L)	Aquatic Feeding Species[f] (mg/L)
Endrin	Mallard Duck	0.3	American Robin	0.732	0.606	5.319	
			American Woodcock	0.536	0.708	5.307	
			Wild Turkey	0.176	5.863	5.369	
			Belted Kingfisher	0.590	1.165	5.459	5.21e-04
			Great Blue Heron	0.236	1.341	5.324	6.00e-04
			Barred Owl	0.351	5.372	5.349	
			Barn Owl	0.404	3.014	5.382	
			Cooper's Hawk	0.412	5.323	5.323	
			Red-tailed Hawk	0.302	0.374	5.315	
Ethanol	Rat	31.9	Short-tailed Shrew	90.203	150.339	410.015	
			Little Brown Bat	113.387	340.161	708.669	
			White-footed Mouse	79.494	514.372	264.979	
			Meadow Vole	63.240	556.513	463.761	
			Cottontail Rabbit	21.243	107.557	219.750	
			Mink	22.560	164.669	227.876	1.55e+02
			Red Fox	13.733	137.333	162.631	
			Whitetail Deer	5.959	193.494	90.994	

Table 12. (continued)

Contaminant and Form	Test Species	Test Species NOAEL[a] (mg/kg • d)	Endpoint Species[b]	Estimated Wildlife NOAEL[c] (mg/kg • d)	Toxicological Benchmarks		
					Diet[d] (mg/kg)	Water[e] (mg/L)	Aquatic Feeding Species[f] (mg/L)
Ethyl Acetate	Rat	90	Short-tailed Shrew	254.492	424.154	1156.782	
			Little Brown Bat	319.901	959.702	1999.378	
			White-footed Mouse	224.277	1451.206	747.591	
			Meadow Vole	178.421	1570.100	1308.417	
			Cottontail Rabbit	59.932	303.453	619.985	
			Mink	63.648	464.584	642.909	
			Red Fox	38.746	387.459	458.833	
			Whitetail Deer	16.812	545.907	256.724	
Fluoride	mink	31.37	Short-tailed Shrew	125.431	209.051	570.140	
NaF			Little Brown Bat	157.668	473.004	985.426	
			White-footed Mouse	110.539	715.251	368.463	
			Meadow Vole	87.938	773.851	644.876	
			Cottontail Rabbit	29.538	149.561	305.569	
			Mink	31.370	228.978	316.869	
			Red Fox	19.096	190.965	226.143	
			Whitetail Deer	8.286	269.049	126.526	

Table 12. (continued)

Contaminant and Form	Test Species	Test Species NOAEL[a] (mg/kg • d)	Endpoint Species[b]	Estimated Wildlife NOAEL[c] (mg/kg • d)	Toxicological Benchmarks		
					Diet[d] (mg/kg)	Water[e] (mg/L)	Aquatic Feeding Species[f] (mg/L)
Fluoride	Screech Owl	7.8	American Robin	10.342	8.562	75.123	
NaF			American Woodcock	7.572	9.995	74.966	
			Wild Turkey	2.484	82.810	75.837	
			Belted Kingfisher	8.336	16.449	77.105	
			Great Blue Heron	3.329	18.941	75.192	
			Barred Owl	4.952	75.872	75.549	
			Barn Owl	5.709	42.566	76.011	
			Cooper's Hawk	5.823	75.179	75.179	
			Red-tailed Hawk	4.267	5.280	75.072	
Formaldehyde	beagle dog	9.4	Short-tailed Shrew	85.339	142.232	387.905	
			Little Brown Bat	107.272	321.817	670.452	
			White-footed Mouse	75.207	486.633	250.690	
			Meadow Vole	59.830	526.503	438.752	
			Cottontail Rabbit	20.097	101.756	207.898	
			Mink	21.343	155.789	215.587	8.61e+01
			Red Fox	12.993	129.927	153.861	
			Whitetail Deer	5.637	183.055	86.086	

Table 12. (continued)

Contaminant and Form	Test Species	Test Species NOAEL[a] (mg/kg • d)	Endpoint Species[b]	Estimated Wildlife NOAEL[c] (mg/kg • d)	Toxicological Benchmarks		
					Diet[d] (mg/kg)	Water[e] (mg/L)	Aquatic Feeding Species[f] (mg/L)
Heptachlor	Rat	0.8	Short-tailed Shrew	2.262	3.770	10.283	
			Little Brown Bat	2.844	8.531	17.772	
			White-footed Mouse	1.994	12.900	6.645	
			Meadow Vole	1.586	13.956	11.630	
			Cottontail Rabbit	0.533	2.697	5.511	
			Mink	0.566	4.130	5.715	3.62e-03
			Red Fox	0.344	3.444	4.079	
			Whitetail Deer	0.149	4.853	2.282	
1,2,3,6,7,8-Hexachloro Dibenzofuran	Rat	0.00016	Short-tailed Shrew	0.00045	0.00075	0.00205	
			Little Brown Bat	0.001	0.002	0.004	
			White-footed Mouse	0.0004	0.00259	0.00133	
			Meadow Vole	0.00032	0.00282	0.00235	
			Cottontail Rabbit	0.00011	0.00056	0.00114	
			Mink	0.00011	0.0008	0.00111	
			Red Fox	0.00007	0.0007	0.00083	
			Whitetail Deer	0.00003	0.00097	0.00046	

Table 12. (continued)

Contaminant and Form	Test Species	Test Species NOAEL[a] (mg/kg • d)	Endpoint Species[b]	Estimated Wildlife NOAEL[c] (mg/kg • d)	Toxicological Benchmarks		
					Diet[d] (mg/kg)	Water[e] (mg/L)	Aquatic Feeding Species[f] (mg/L)
Lead	Rat	8	Short-tailed Shrew	22.622	37.703	102.825	
Lead Acetate			Little Brown Bat	28.436	85.307	177.723	
			White-footed Mouse	19.936	128.996	66.453	
			Meadow Vole	15.860	139.564	116.304	
			Cottontail Rabbit	5.327	26.974	55.110	
			Mink	5.658	41.296	57.147	9.03e-01
			Red Fox	3.444	34.441	40.785	
			Whitetail Deer	1.494	48.525	22.820	
Lead	American Kestrel	3.85	American Robin	4.576	3.789	33.243	
Metal			American Woodcock	3.351	4.423	33.174	
			Wild Turkey	1.099	36.644	33.558	
			Belted Kingfisher	3.689	7.279	34.121	1.61e-01
			Great Blue Heron	1.473	8.382	33.274	1.85e-01
			Barred Owl	2.192	33.575	33.432	
			Barn Owl	2.526	18.837	33.637	
			Cooper's Hawk	2.577	33.269	33.269	
			Red-tailed Hawk	1.888	2.336	33.221	

Table 12. (continued)

Contaminant and Form	Test Species	Test Species NOAEL[a] (mg/kg • d)	Endpoint Species[b]	Estimated Wildlife NOAEL[c] (mg/kg • d)	Toxicological Benchmarks		
					Diet[d] (mg/kg)	Water[e] (mg/L)	Aquatic Feeding Species[f] (mg/L)
Lindane (Gamma-BHC)	Rat	8	Short-tailed Shrew	22.622	37.703	102.825	
			Little Brown Bat	28.436	85.307	177.723	
			White-footed Mouse	19.936	128.996	66.453	
			Meadow Vole	15.860	139.564	116.304	
			Cottontail Rabbit	5.327	26.974	55.110	
			Mink	5.658	41.296	57.147	1.04e-01
			Red Fox	3.444	34.441	40.785	
			Whitetail Deer	1.494	48.525	22.820	
Lindane (Gamma-BHC)	mallard duck	2	American Robin	4.661	3.859	33.859	
			American Woodcock	3.413	4.505	33.788	
			Wild Turkey	1.120	37.323	34.180	
			Belted Kingfisher	3.757	7.414	34.752	1.87e-02
			Great Blue Heron	1.500	8.537	33.890	2.16e-02
			Barred Owl	2.232	34.197	34.051	
			Barn Owl	2.573	19.185	34.260	
			Cooper's Hawk	2.624	33.885	33.885	
			Red-tailed Hawk	1.923	2.380	33.836	

Table 12. (continued)

Contaminant and Form	Test Species	Test Species NOAEL[a] (mg/kg • d)	Endpoint Species[b]	Estimated Wildlife NOAEL[c] (mg/kg • d)	Toxicological Benchmarks		
					Diet[d] (mg/kg)	Water[e] (mg/L)	Aquatic Feeding Species[f] (mg/L)
Lithium	Rat	9.39	Short-tailed Shrew	26.552	44.253	120.691	
Lithium Carbonate			Little Brown Bat	33.376	100.129	208.602	
			White-footed Mouse	23.400	151.409	77.999	
			Meadow Vole	18.615	163.814	136.512	
			Cottontail Rabbit	6.253	31.660	64.685	
			Mink	6.641	48.472	67.077	
			Red Fox	4.042	40.425	47.872	
			Whitetail Deer	1.754	56.956	26.785	
Manganese	Rat	88	Short-tailed Shrew	248.837	414.728	1131.076	
Manganese Oxide			Little Brown Bat	312.792	938.375	1954.948	
			White-footed Mouse	219.293	1418.957	730.978	
			Meadow Vole	174.456	1535.209	1279.341	
			Cottontail Rabbit	58.600	296.709	606.208	
			Mink	62.234	454.260	628.622	
			Red Fox	37.885	378.849	448.637	
			Whitetail Deer	16.438	533.776	251.019	

Table 12. (continued)

Contaminant and Form	Test Species	Test Species NOAEL[a] (mg/kg • d)	Endpoint Species[b]	Estimated Wildlife NOAEL[c] (mg/kg • d)	Toxicological Benchmarks		
					Diet[d] (mg/kg)	Water[e] (mg/L)	Aquatic Feeding Species[f] (mg/L)
Mercury	Rat	0.0064	Short-tailed Shrew	0.018	0.030	0.082	
Mercuric Chloride			Little Brown Bat	0.023	0.068	0.142	
			White-footed Mouse	0.016	0.103	0.053	
			Meadow Vole	0.013	0.112	0.093	
			Cottontail Rabbit	0.004	0.022	0.044	
			Mink	0.005	0.033	0.046	
			Red Fox	0.003	0.028	0.033	
			Whitetail Deer	0.001	0.039	0.018	
Mercury	mouse	13.2	Short-tailed Shrew	16.593	27.654	75.421	
Mercuric Sulfide			Little Brown Bat	20.857	62.571	130.357	
			White-footed Mouse	14.623	94.617	48.742	
			Meadow Vole	11.633	102.368	85.307	
			Cottontail Rabbit	3.907	19.785	40.422	
			Mink	4.150	30.291	41.917	
			Red Fox	2.526	25.262	29.916	
			Whitetail Deer	1.096	35.593	16.738	

Table 12. (continued)

Contaminant and Form	Test Species	Test Species NOAEL[a] (mg/kg · d)	Endpoint Species[b]	Estimated Wildlife NOAEL[c] (mg/kg · d)	Toxicological Benchmarks		
					Diet[d] (mg/kg)	Water[e] (mg/L)	Aquatic Feeding Species[f] (mg/L)
Mercury	Rat	0.032	Short-tailed Shrew	0.090	0.151	0.411	
Methyl Mercury Chloride			Little Brown Bat	0.114	0.341	0.711	
			White-footed Mouse	0.080	0.516	0.266	
			Meadow Vole	0.063	0.558	0.465	
			Cottontail Rabbit	0.021	0.108	0.220	
			Whitetail Deer	0.006	0.194	0.091	
Mercury	mink	0.015	Mink	0.015	0.109	0.152	1.82e-06
Methyl Mercury Chloride			Red Fox	0.009	0.091	0.108	
Mercury	mallard duck	0.0064	American Robin	0.015	0.012	0.108	
Methyl Mercury Dicyandiamide			American Woodcock	0.011	0.014	0.108	
			Wild Turkey	0.004	0.119	0.109	
			Belted Kingfisher	0.012	0.024	0.111	3.95e-07
			Great Blue Heron	0.005	0.027	0.108	4.55e-07
			Barred Owl	0.007	0.109	0.109	
			Barn Owl	0.008	0.061	0.110	
			Cooper's Hawk	0.008	0.108	0.108	
			Red-tailed Hawk	0.006	0.008	0.108	

Table 12. (continued)

Contaminant and Form	Test Species	Test Species NOAEL[a] (mg/kg • d)	Endpoint Species[b]	Estimated Wildlife NOAEL[c] (mg/kg • d)	Toxicological Benchmarks		
					Diet[d] (mg/kg)	Water[e] (mg/L)	Aquatic Feeding Species[f] (mg/L)
Methanol	Rat	50	Short-tailed Shrew	141.385	235.641	642.657	
			Little Brown Bat	177.723	533.168	1110.766	
			White-footed Mouse	124.599	806.226	415.328	
			Meadow Vole	99.123	872.278	726.898	
			Cottontail Rabbit	33.296	168.585	344.436	
			Mink	35.360	258.102	357.172	2.95e+02
			Red Fox	21.526	215.255	254.907	
			Whitetail Deer	9.340	303.282	142.624	
Methoxychlor	Rat	4	Short-tailed Shrew	11.311	18.851	51.413	
			Little Brown Bat	14.218	42.653	88.861	
			White-footed Mouse	9.968	64.498	33.226	
			Meadow Vole	7.930	69.782	58.152	
			Cottontail Rabbit	2.664	13.487	27.555	
			Mink	2.829	20.648	28.574	
			Red Fox	1.722	17.220	20.393	
			Whitetail Deer	0.747	24.263	11.410	

Table 12. (continued)

Contaminant and Form	Test Species	Test Species NOAEL[a] (mg/kg • d)	Endpoint Species[b]	Estimated Wildlife NOAEL[c] (mg/kg • d)	Toxicological Benchmarks		
					Diet[d] (mg/kg)	Water[e] (mg/L)	Aquatic Feeding Species[f] (mg/L)
Methylene Chloride	Rat	5.85	Short-tailed Shrew	16.542	27.570	75.191	
			Little Brown Bat	20.794	62.381	129.960	
			White-footed Mouse	14.578	94.328	48.593	
			Meadow Vole	11.597	102.057	85.047	
			Cottontail Rabbit	3.896	19.724	40.299	
			Mink	4.137	30.198	41.789	5.06e+00
			Red Fox	2.518	25.185	29.824	
			Whitetail Deer	1.093	35.484	16.687	
Methyl Ethyl Ketone	Rat	1771	Short-tailed Shrew	5007.839	8346.398	22762.905	
			White-footed Mouse	4413.279	28556.510	14710.930	
			Little Brown Bat	0.000	0.000	0.000	
			Meadow Vole	3510.919	30896.087	25746.739	
			Cottontail Rabbit	1179.327	5971.274	12199.930	
			Mink	1252.451	9141.980	12651.022	5.38e+03
			Red Fox	762.433	7624.332	9028.814	
			Whitetail Deer	330.823	10742.235	5051.754	

Table 12. (continued)

Contaminant and Form	Test Species	Test Species NOAEL[a] (mg/kg • d)	Endpoint Species[b]	Estimated Wildlife NOAEL[c] (mg/kg • d)	Toxicological Benchmarks		
					Diet[d] (mg/kg)	Water[e] (mg/L)	Aquatic Feeding Species[f] (mg/L)
4-Methyl 2-Pentanone	Rat	25	Short-tailed Shrew	70.692	117.820	321.328	
			Little Brown Bat	88.861	266.584	555.383	
			White-footed Mouse	62.299	403.113	207.664	
			Meadow Vole	49.561	436.139	363.449	
			Cottontail Rabbit	16.648	84.292	172.218	
			Mink	17.680	129.051	178.586	2.37e+01
			Red Fox	10.763	107.628	127.454	
			Whitetail Deer	4.670	151.641	71.312	
Nickel	Rat	40	Short-tailed Shrew	113.108	188.513	514.125	
Nickel Sulfate Hexahydrate			Little Brown Bat	142.178	426.534	888.613	
			White-footed Mouse	99.679	644.980	332.263	
			Meadow Vole	79.298	697.822	581.519	
			Cottontail Rabbit	26.636	134.868	275.549	
			Mink	28.288	206.482	285.737	1.93e+00
			Red Fox	17.220	172.204	203.926	
			Whitetail Deer	7.472	242.625	114.099	

Table 12. (continued)

Contaminant and Form	Test Species	Test Species NOAEL[a] (mg/kg • d)	Endpoint Species[b]	Estimated Wildlife NOAEL[c] (mg/kg • d)	Toxicological Benchmarks		
					Diet[d] (mg/kg)	Water[e] (mg/L)	Aquatic Feeding Species[f] (mg/L)
Nickel	Mallard Duckling	77.4	American Robin	166.325	137.710	1208.209	
Nickel Sulfate			American Woodcock	121.787	160.758	1205.687	
			Wild Turkey	39.955	1331.822	1219.668	
			Belted Kingfisher	134.065	264.554	1240.097	2.49e+00
			Great Blue Heron	53.534	304.632	1209.315	2.87e+00
			Barred Owl	79.648	1220.255	1215.063	
			Barn Owl	91.819	684.601	1222.502	
			Cooper's Hawk	93.645	1209.129	1209.129	
			Red-tailed Hawk	68.627	84.916	1207.401	
Niobium	mouse	0.1166	Short-tailed Shrew	0.147	0.244	0.666	
Sodium Niobate			Little Brown Bat	0.184	0.553	1.152	
			White-footed Mouse	0.129	0.836	0.431	
			Meadow Vole	0.103	0.904	0.754	
			Cottontail Rabbit	0.035	0.175	0.357	
			Mink	0.037	0.268	0.370	
			Red Fox	0.022	0.223	0.264	
			Whitetail Deer	0.010	0.314	0.148	

Table 12. (continued)

Contaminant and Form	Test Species	Test Species NOAEL[a] (mg/kg • d)	Endpoint Species[b]	Estimated Wildlife NOAEL[c] (mg/kg • d)	Toxicological Benchmarks		
					Diet[d] (mg/kg)	Water[e] (mg/L)	Aquatic Feeding Species[f] (mg/L)
Nitrate	Guinea Pig	507	Short-tailed Shrew	1928.780	3214.634	8767.182	
Potassium Nitrate			Little Brown Bat	2424.499	7273.498	15153.121	
			White-footed Mouse	1699.783	10998.599	5665.945	
			Meadow Vole	1352.240	11899.712	9916.427	
			Cottontail Rabbit	454.216	2299.829	4698.789	
			Mink	482.385	3521.059	4872.577	
			Red Fox	293.649	2936.493	3477.426	
			Whitetail Deer	127.414	4137.299	1945.649	
1,2,3,4,8-Pentachloro Dibenzofuran	Rat	0.048	Short-tailed Shrew	0.136	0.226	0.617	
			Little Brown Bat	0.171	0.512	1.066	
			White-footed Mouse	0.120	0.774	0.399	
			Meadow Vole	0.095	0.837	0.698	
			Cottontail Rabbit	0.032	0.162	0.331	
			Mink	0.034	0.248	0.343	
			Red Fox	0.021	0.207	0.245	
			Whitetail Deer	0.009	0.291	0.137	

Table 12. (continued)

Contaminant and Form	Test Species	Test Species NOAEL[a] (mg/kg · d)	Endpoint Species[b]	Estimated Wildlife NOAEL[c] (mg/kg · d)	Toxicological Benchmarks		
					Diet[d] (mg/kg)	Water[e] (mg/L)	Aquatic Feeding Species[f] (mg/L)
1,2,3,7,8-Pentachloro Dibenzofuran	Rat	0.00016	Short-tailed Shrew	0.00045	0.00075	0.00205	
			Little Brown Bat	0.0005687	0.0017061	0.0035544	
			White-footed Mouse	0.0004	0.00259	0.00133	
			Meadow Vole	0.00032	0.00282	0.00235	
			Cottontail Rabbit	0.00011	0.00056	0.00114	
			Mink	0.00011	0.0008	0.00111	
			Red Fox	0.00007	0.0007	0.00083	
			Whitetail Deer	0.00003	0.00097	0.00046	
2,3,4,7,8-Pentachloro Dibenzofuran	Rat	0.000016	Short-tailed Shrew	0.0000452	0.0000753	0.0002055	
			Little Brown Bat	0.0000567	0.00017	0.00035	
			White-footed Mouse	0.0000399	0.0002582	0.000133	
			Meadow Vole	0.0000317	0.000279	0.0002325	
			Cottontail Rabbit	0.0000107	0.0000542	0.0001107	
			Mink	0.0000113	0.0000825	0.0001141	
			Red Fox	0.0000069	0.000069	0.0000817	
			Whitetail Deer	0.000003	0.0000974	0.0000458	

Table 12. (continued)

Contaminant and Form	Test Species	Test Species NOAEL[a] (mg/kg • d)	Endpoint Species[b]	Estimated Wildlife NOAEL[c] (mg/kg • d)	Toxicological Benchmarks		
					Diet[d] (mg/kg)	Water[e] (mg/L)	Aquatic Feeding Species[f] (mg/L)
Pentachloronitrobenzene	Chicken	7.07	American Robin	18.836	15.595	136.827	
			American Woodcock	13.792	18.206	136.542	
			Wild Turkey	4.525	150.827	138.125	
			Belted Kingfisher	15.182	29.960	140.438	1.16e-02
			Great Blue Heron	6.063	34.499	136.953	1.34e-02
			Barred Owl	9.020	138.192	137.604	
			Barn Owl	10.398	77.530	138.446	
			Cooper's Hawk	10.605	136.931	136.931	
			Red-tailed Hawk	7.772	9.617	136.736	
Selenium	mouse	0.075	Short-tailed Shrew	0.094	0.157	0.429	
Selanate			Little Brown Bat	0.119	0.356	0.741	
			White-footed Mouse	0.083	0.538	0.277	
			Meadow Vole	0.066	0.582	0.485	
			Cottontail Rabbit	0.022	0.112	0.230	
			Mink	0.024	0.172	0.238	6.62e-05
			Red Fox	0.014	0.144	0.170	
			Whitetail Deer	0.006	0.202	0.095	

Table 12. (continued)

Contaminant and Form	Test Species	Test Species NOAEL[a] (mg/kg • d)	Endpoint Species[b]	Estimated Wildlife NOAEL[c] (mg/kg • d)	Toxicological Benchmarks		
					Diet[d] (mg/kg)	Water[e] (mg/L)	Aquatic Feeding Species[f] (mg/L)
Selenium	mallard duck	0.5	American Robin	1.165	0.965	8.465	
Sodium Selanite			American Woodcock	0.853	1.126	8.447	
			Wild Turkey	0.280	9.331	8.545	
			Belted Kingfisher	0.939	1.853	8.688	7.13e-04
			Great Blue Heron	0.375	2.134	8.473	8.21e-04
			Barred Owl	0.558	8.549	8.513	
			Barn Owl	0.643	4.796	8.565	
			Cooper's Hawk	0.656	8.471	8.471	
			Red-tailed Hawk	0.481	0.595	8.459	
Selenium	Mallard Duck	0.4	American Robin	0.932	0.772	6.772	
Selanomethionine			American Woodcock	0.683	0.901	6.758	
			Wild Turkey	0.224	7.465	6.836	
			Belted Kingfisher	0.751	1.483	6.950	
			Great Blue Heron	0.300	1.707	6.778	
			Barred Owl	0.446	6.839	6.810	
			Barn Owl	0.515	3.837	6.852	
			Cooper's Hawk	0.525	6.777	6.777	
			Red-tailed Hawk	0.385	0.476	6.767	

Table 12. (continued)

Contaminant and Form	Test Species	Test Species NOAEL[a] (mg/kg • d)	Endpoint Species[b]	Estimated Wildlife NOAEL[c] (mg/kg • d)	Toxicological Benchmarks		
					Diet[d] (mg/kg)	Water[e] (mg/L)	Aquatic Feeding Species[f] (mg/L)
Strontium (stable)	Rat	263	Short-tailed Shrew	743.682	1239.471	3380.375	
Strontium Chloride			Little Brown Bat	934.820	2804.461	5842.627	
			White-footed Mouse	655.388	4240.747	2184.627	
			Meadow Vole	521.384	4588.182	3823.485	
			Cottontail Rabbit	175.134	886.756	1811.734	
			Mink	185.994	1357.618	1878.723	
			Red Fox	113.224	1132.241	1340.812	
			Whitetail Deer	49.128	1595.261	750.204	
2,3,7,8-Tetrachloro Dibenzodioxin	Rat	0.000001	Short-tailed Shrew	0.0000028	0.00000467	0.00001273	
			Little Brown Bat	0.000003554	0.000010662	0.000022213	
			White-footed Mouse	0.0000025	0.00001618	0.00000833	
			Meadow Vole	0.000002	0.0000176	0.00001467	
			Cottontail Rabbit	0.0000007	0.00000354	0.00000724	
			Mink	0.0000007	0.00000511	0.00000707	5.89e-11
			Red Fox	0.000000431	0.00000431	0.0000051	
			Whitetail Deer	0.000000187	0.00000607	0.00000286	

Table 12. (continued)

Contaminant and Form	Test Species	Test Species NOAEL[a] (mg/kg • d)	Endpoint Species[b]	Estimated Wildlife NOAEL[c] (mg/kg • d)	Toxicological Benchmarks		
					Diet[d] (mg/kg)	Water[e] (mg/L)	Aquatic Feeding Species[f] (mg/L)
2,3,7,8-Tetrachloro Dibenzodioxin	Ring-necked Pheasant	0.000014	American Robin	0.0000326	0.000027	0.0002368	
			American Woodcock	0.0000239	0.0000315	0.0002366	
			Wild Turkey	0.0000078	0.00026	0.0002381	
			Belted Kingfisher	0.0000263	0.0000519	0.0002433	5.99e-10
			Great Blue Heron	0.0000105	0.0000598	0.0002372	6.89e-10
			Barred Owl	0.0000156	0.000239	0.000238	
			Barn Owl	0.000018	0.0001342	0.0002397	
			Cooper's Hawk	0.0000184	0.0002376	0.0002376	
			Red-tailed Hawk	0.0000135	0.0000167	0.0002375	
2,3,7,8-Tetrachloro Dibenzofuran	Chicken	1.0e-06	American Robin	0.0000012	0.000001	0.0000087	
			American Woodcock	0.0000009	0.0000012	0.0000089	
			Wild Turkey	0.0000003	0.00001	0.0000092	
			Belted Kingfisher	0.0000009	0.0000018	0.0000083	
			Great Blue Heron	0.0000004	0.0000023	0.000009	
			Barred Owl	0.0000006	0.0000092	0.0000092	
			Barn Owl	0.0000006	0.0000045	0.000008	
			Cooper's Hawk	0.0000007	0.000009	0.000009	
			Red-tailed Hawk	0.0000005	0.0000006	0.0000088	

Table 12. (continued)

Contaminant and Form	Test Species	Test Species NOAEL[a] (mg/kg • d)	Endpoint Species[b]	Estimated Wildlife NOAEL[c] (mg/kg • d)	Toxicological Benchmarks		
					Diet[d] (mg/kg)	Water[e] (mg/L)	Aquatic Feeding Species[f] (mg/L)
1,1,2,2-Tetrachloroethylene	mouse	1.4	Short-tailed Shrew	1.760	2.933	7.999	
			Little Brown Bat	2.212	6.636	13.826	
			White-footed Mouse	1.551	10.035	5.170	
			Meadow Vole	1.234	10.857	9.048	
			Cottontail Rabbit	0.414	2.098	4.287	
			Mink	0.440	3.213	4.446	1.42e-02
			Red Fox	0.268	2.679	3.173	
			Whitetail Deer	0.116	3.775	1.775	
Thallium	Rat	0.0074	Short-tailed Shrew	0.021	0.035	0.096	
Thallium Sulfate			Little Brown Bat	0.027	0.080	0.167	
			White-footed Mouse	0.019	0.121	0.062	
			Meadow Vole	0.015	0.131	0.109	
			Cottontail Rabbit	0.005	0.025	0.052	
			Mink	0.005	0.039	0.054	1.12e-03
			Red Fox	0.003	0.032	0.038	
			Whitetail Deer	0.001	0.045	0.021	

Table 12. (continued)

Contaminant and Form	Test Species	Test Species NOAEL[a] (mg/kg • d)	Endpoint Species[b]	Estimated Wildlife NOAEL[c] (mg/kg • d)	Toxicological Benchmarks		
					Diet[d] (mg/kg)	Water[e] (mg/L)	Aquatic Feeding Species[f] (mg/L)
Toluene	Rat	25.98	Short-tailed Shrew	32.657	54.429	148.441	
			Little Brown Bat	41.050	123.151	256.566	
			White-footed Mouse	28.780	186.223	95.933	
			Meadow Vole	22.895	201.479	167.900	
			Cottontail Rabbit	7.691	38.940	79.558	
			Mink	8.168	59.617	82.501	8.44e-01
			Red Fox	4.972	49.721	58.880	
			Whitetail Deer	2.157	70.053	32.944	
Toxaphene	Rat	8	Short-tailed Shrew	22.622	37.703	102.825	
			Little Brown Bat	28.436	85.307	177.723	
			White-footed Mouse	19.936	128.996	66.453	
			Meadow Vole	15.860	139.564	116.304	
			Cottontail Rabbit	5.327	26.974	55.110	
			Mink	5.658	41.296	57.147	1.02e-02
			Red Fox	3.444	34.441	40.785	
			Whitetail Deer	1.494	48.525	22.820	

Table 12. (continued)

Contaminant and Form	Test Species	Test Species NOAEL[a] (mg/kg • d)	Endpoint Species[b]	Estimated Wildlife NOAEL[c] (mg/kg • d)	Toxicological Benchmarks		
					Diet[d] (mg/kg)	Water[e] (mg/L)	Aquatic Feeding Species[f] (mg/L)
1,1,1-Trichloroethane	mouse	1000	Short-tailed Shrew	1322.610	2204.350	6011.864	
			Little Brown Bat	1662.540	4987.620	10390.875	
			White-footed Mouse	1165.580	7541.988	3885.267	
			Meadow Vole	927.260	8159.888	6799.907	
			Cottontail Rabbit	311.470	1577.063	3222.103	
			Mink	330.780	2414.453	3341.212	5.17e+01
			Red Fox	201.360	2013.600	2384.526	
			Whitetail Deer	87.370	2837.014	1334.164	
Trichloroethylene	mouse	0.7	Short-tailed Shrew	0.880	1.467	4.000	
			Little Brown Bat	1.106	3.318	6.913	
			White-footed Mouse	0.775	5.018	2.585	
			Meadow Vole	0.617	5.429	4.524	
			Cottontail Rabbit	0.207	1.049	2.144	
			Mink	0.220	1.606	2.223	3.88e-02
			Red Fox	0.134	1.340	1.586	
			Whitetail Deer	0.058	1.888	0.888	

Table 12. (continued)

Contaminant and Form	Test Species	Test Species NOAEL[a] (mg/kg • d)	Endpoint Species[b]	Estimated Wildlife NOAEL[c] (mg/kg • d)	Toxicological Benchmarks		
					Diet[d] (mg/kg)	Water[e] (mg/L)	Aquatic Feeding Species[f] (mg/L)
Uranium	mouse	3.07	Short-tailed Shrew	3.772	6.287	17.146	
Uranyl Acetate			Little Brown Bat	4.742	14.225	29.635	
			White-footed Mouse	3.324	21.510	11.081	
			Meadow Vole	2.645	23.273	19.394	
			Cottontail Rabbit	0.888	4.498	9.190	
			Mink	0.943	6.886	9.529	
			Red Fox	0.574	5.743	6.801	
			Whitetail Deer	0.249	8.092	3.805	
Uranium	black duck	16	American Robin	40.138	33.233	291.570	
depleted metal			American Woodcock	29.390	38.795	290.962	
			Wild Turkey	9.642	321.403	294.337	
			Belted Kingfisher	32.353	63.843	299.265	
			Great Blue Heron	12.919	73.515	291.838	
			Barred Owl	19.221	294.477	293.224	
			Barn Owl	22.158	165.211	295.019	
			Cooper's Hawk	22.599	291.791	291.791	
			Red-tailed Hawk	16.561	20.492	291.375	

Table 12. (continued)

Contaminant and Form	Test Species	Test Species NOAEL[a] (mg/kg • d)	Endpoint Species[b]	Estimated Wildlife NOAEL[c] (mg/kg • d)	Toxicological Benchmarks		
					Diet[d] (mg/kg)	Water[e] (mg/L)	Aquatic Feeding Species[f] (mg/L)
Vanadium	Rat	0.21	Short-tailed Shrew	0.538	0.897	2.447	
Sodium Metavanadate			Little Brown Bat	0.677	2.030	4.229	
			White-footed Mouse	0.474	3.070	1.581	
			Meadow Vole	0.377	3.321	2.768	
			Cottontail Rabbit	0.127	0.642	1.311	
			Mink	0.135	0.983	1.360	
			Red Fox	0.082	0.820	0.971	
			Whitetail Deer	0.036	1.155	0.543	
Vanadium	Mallard Duck	11.38	American Robin	27.932	23.126	202.902	
Vanadyl Sulfate			American Woodcock	20.452	26.997	202.478	
			Wild Turkey	6.710	223.663	204.828	
			Belted Kingfisher	22.514	44.428	208.256	
			Great Blue Heron	8.990	51.159	203.089	
			Barred Owl	13.376	204.924	204.052	
			Barn Owl	15.420	114.969	205.302	
			Cooper's Hawk	15.726	203.057	203.057	
			Red-tailed Hawk	11.525	14.260	202.766	

Table 12. (continued)

Contaminant and Form	Test Species	Test Species NOAEL[a] (mg/kg • d)	Endpoint Species[b]	Estimated Wildlife NOAEL[c] (mg/kg • d)	Toxicological Benchmarks		
					Diet[d] (mg/kg)	Water[e] (mg/L)	Aquatic Feeding Species[f] (mg/L)
Vinyl Chloride	Rat	0.17	Short-tailed Shrew	0.481	0.801	2.185	
			Little Brown Bat	0.604	1.813	3.777	
			White-footed Mouse	0.424	2.741	1.412	
			Meadow Vole	0.337	2.966	2.471	
			Cottontail Rabbit	0.113	0.573	1.171	
			Mink	0.120	0.878	1.214	1.24e-01
			Red Fox	0.073	0.732	0.867	
			Whitetail Deer	0.032	1.031	0.485	
Xylene (mixed isomers)	mouse	2.06	Short-tailed Shrew	2.589	4.316	11.770	
			Little Brown Bat	3.255	9.765	20.344	
			White-footed Mouse	2.282	14.766	7.607	
			Meadow Vole	1.815	15.976	13.313	
			Cottontail Rabbit	0.610	3.088	6.308	
			Mink	0.648	4.727	6.542	2.96e-02
			Red Fox	0.394	3.942	4.669	
			Whitetail Deer	0.171	5.555	2.612	

Table 12. (continued)

Contaminant and Form	Test Species	Test Species NOAEL[a] (mg/kg • d)	Endpoint Species[b]	Estimated Wildlife NOAEL[c] (mg/kg • d)	Toxicological Benchmarks		
					Diet[d] (mg/kg)	Water[e] (mg/L)	Aquatic Feeding Species[f] (mg/L)
Zinc	Rat	160	Short-tailed Shrew	452.430	754.051	2056.502	
Zinc Oxide			Little Brown Bat	568.712	1706.136	3554.450	
			White-footed Mouse	398.715	2579.922	1329.051	
			Meadow Vole	317.192	2791.290	2326.075	
			Cottontail Rabbit	106.546	539.471	1102.196	
			Mink	113.152	825.927	1142.949	8.54e-01
			Red Fox	68.882	688.816	815.703	
			Whitetail Deer	29.888	970.501	456.398	
Zinc	Mallard Duck	3	American Robin	6.992	5.789	50.788	
Zinc Carbonate			American Woodcock	5.119	6.758	50.682	
			Wild Turkey	1.680	55.985	51.270	
			Belted Kingfisher	5.636	11.121	52.129	1.15e-02
			Great Blue Heron	2.250	12.806	50.835	1.33e-02
			Barred Owl	3.348	51.295	51.077	
			Barn Owl	3.860	28.778	51.389	
			Cooper's Hawk	3.936	50.827	50.827	
			Red-tailed Hawk	2.885	3.570	50.754	

Table 12. (continued)

Contaminant and Form	Test Species	Test Species NOAEL[a] (mg/kg • d)	Endpoint Species[b]	Estimated Wildlife NOAEL[c] (mg/kg • d)	Toxicological Benchmarks		
					Diet[d] (mg/kg)	Water[e] (mg/L)	Aquatic Feeding Species[f] (mg/L)
Zirconium	mouse	1.738	Short-tailed Shrew	2.185	3.641	9.930	
Zirconium Sulfate			Little Brown Bat	2.746	8.239	17.164	
			White-footed Mouse	1.925	12.458	6.418	
			Meadow Vole	1.532	13.479	11.232	
			Cottontail Rabbit	0.514	2.605	5.322	
			Mink	0.546	3.988	5.519	
			Red Fox	0.333	3.326	3.939	
			Whitetail Deer	0.144	4.686	2.204	

[a] See Appendix A for NOAEL derivation, study duration and study endpoint.
[b] See Appendix B for body weights, food and water consumption rates.
[c] Calculated using Equation 4.
[d] Calculated using Equation 8.
[e] Calculated using Equation 19.
[f] Combined food and water benchmark for aquatic-feeding species. Calculated using Equation 26.

Table 13. Use of benchmarks in a screening assessment

Analyte	Contaminant Concentrations in Media			Benchmarks for Meadow Vole		Comparison of Media Concentrations to Benchmarks			
						Water		Diet	
	Water (mg/L)	Soil (mg/kg)	Estimated in Plants[a] (mg/kg)	Water (mg/L)	Diet (mg/kg)	HQ[b]	Retain as COPC	HQ[b]	Retain as COP
Arsenic	0.038	131	5.24	0.814	0.977	0.047	NO	5.36	YES
Lead	0.069	18.8	0.85	116.3	139.56	0.0006	NO	0.006	NO
Mercury[c]	0.005	0.71	0.64	0.465	0.558	0.011	NO	1.15	YES
Selenium	0.02	14.8	0.37	0.485	0.582	0.041	NO	0.64	NO

[a] Estimates using plant uptake factors for foliage from Baes et al. (1984).
[b] HQ = Hazard Quotient = Media Concentration/Benchmark.
[c] Mercury assumed to be in the form of Methyl Mercury.

Table 14. Use of benchmarks in a baseline assessment

Analyte	Contaminant Concentrations in Media			Contaminant Exposure (mg/kg bw/d)				NOAEL for Meadow Vole	HQ[a]
	Water (mg/L)	Soil (mg/kg)	Plants (mg/kg)	Water	Soil	Diet	Total		
Arsenic	0.038	131	1.77	0.0052	0.298	0.201	0.504	0.111	4.54
Lead	0.069	18.8	1.07	0.0094	0.043	0.122	0.174	15.86	0.01
Mercury[b]	0.005	0.71	0.06	0.0007	0.0016	0.007	0.0093	0.063	0.15
Selenium	0.02	14.8	23.61	0.003	0.034	2.68	2.717	0.066	41.1

[a] HQ = Hazard Quotient = Total Exposure/Benchmark.
[b] Mercury assumed to be in the form of Methyl Mercury.

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APPENDIX A

Descriptions of Studies Used to Calculate Benchmarks

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APPENDIX A. Descriptions of Studies Used to Calculate Benchmarks

Compound: Acetone
Form: not applicable
Reference: EPA 1986c
Test Species: Rat
Body weight: 0.35 kg (EPA 1988a)
Food Consumption: 0.028 kg/d (calculated using allometric equation from EPA 1988a)
Study Duration: 90 days (<1 yr and not during a critical lifestage=subchronic).
Endpoint: Liver and kidney damage
Exposure Route: oral intubation
Dosage: three dose levels:
100, 500, and 2500 mg/kg/d; NOAEL = 100 mg/kg/d
Calculations: not applicable
Comments: Significant tubular degeneration of the kidneys and increases in kidney weights were observed at the 500 and 2500 mg/kg/d dose levels; liver weights were increased at the 2500 mg/kg/d level. Because no significant differences were observed at the 100 mg/kg/d dose level and the study considered exposure for 90 days and did not include critical lifestages (reproduction), this dose was considered to be a subchronic NOAEL. A chronic NOAEL was estimated by multiplying the subchronic NOAEL by a subchronic to chronic uncertainty factor of 0.1.
Final NOAEL: 10 mg/kg/d

Compound: Aldrin
Form: not applicable
Reference: Treon and Cleveland 1955
Test Species: Rat
Body weight: 0.35 kg (EPA 1988a)
Food Consumption: 0.028 kg/d (calculated using allometric equation from EPA 1988a)
Exposure Duration: 3 generations (>1 yr and during a critical lifestage = chronic).
Endpoint: reproduction
Exposure Route: oral in diet
Dosage: three dose levels:
2.5, 12.5, and 25.0 ppm; NOAEL = 2.5 ppm
Calculations:

$$\left[\frac{2.5 mg\ Aldrin}{kg\ food}\ x\ \frac{28 g\ food}{day}\ x\ \frac{1 kg}{1000 g}\right] / \ 0.35\ kg\ BW = 0.2\ mg/kg/d$$

Comments: Because no significant differences were observed at the 2.5 ppm dose level and the study considered exposure throughout 3 generations including critical lifestages (reproduction), this dose was considered to be a chronic NOAEL.

Final NOAEL: 0.2 mg/kg/d

Compound: Aluminum
Form: $AlCl_3$
Reference: Ondreicka et al. 1966
Test Species: Mouse
Body weight: 0.03 kg (EPA 1988a)
Exposure Duration: 3 generations (>1 yr and during a critical lifestage = chronic).
Endpoint: reproduction
Exposure Route: oral in water
Dosage: one dose level:
19.3 mg Al /kg/d = LOAEL
Calculations: not applicable

Comments: While there were no effects on the number of litters or number of offspring per litter, growth of generations 2 and 3 was significantly reduced. Therefore, this dose was considered to be a chronic LOAEL. A chronic NOAEL was estimated by multiplying the chronic LOAEL by a LOAEL-NOAEL uncertainty factor of 0.1.

Final NOAEL: 1.93 mg/kg/d

Compound: Aluminum
Form: $Al_2(SO_4)_3$
Reference: Carriere et al. 1986
Test Species: Ringed Dove
Body weight: 0.155 kg (Terres 1980)
Food Consumption: 0.01727 kg/d (calculated using allometric equation from Nagy 1987)
Exposure Duration: 4 months (>10 wk and during a critical lifestage = chronic).
Endpoint: reproduction
Exposure Route: oral in diet
Dosage: one dose level:
1000 ppm Al (as $Al_2(SO_4)_3$)= NOAEL
Calculations:

$$\left[\frac{1000\,mg\ Al}{kg\ food}\ x\ \frac{17.27\,g\ food}{day}\ x\ \frac{1\,kg}{1000\,g}\right]\ /\ 0.155\ kg\ BW\ =\ 111.4\ mg/kg/d$$

Comments: Because no significant differences were observed at the 1000 ppm dose level and the study considered exposure over 4 months including critical lifestages (reproduction), this dose was considered to be a chronic NOAEL.

Final NOAEL: 111.4 mg/kg/d

Compound: Antimony
Form: Antimony Potassium Tartrate
Reference: Schroeder et al. 1968b
Test Species: Mouse
Body weight: 0.03 kg (EPA 1988a)
Water Consumption: 0.0075 L/d (calculated using allometric equation from EPA 1988a)
Exposure Duration: lifetime (>1 yr = chronic).
Endpoint: lifespan, longevity
Exposure Route: oral in water
Dosage: one dose level:
5 ppm Sb = LOAEL
Calculations:

$$\left[\frac{5 mg\ Sb}{L\ water} x \frac{7.5 mL\ water}{day} x \frac{1 L}{1000 mL}\right] / 0.03\ kg\ BW = 1.25\ mg/kg/d$$

Comments: Because median lifespan was reduced among female mice exposed to the 5 ppm dose level and the study considered exposure throughout the entire lifespan, this dose was considered to be a chronic LOAEL. A chronic NOAEL was estimated by multiplying the chronic LOAEL by a LOAEL-NOAEL uncertainty factor of 0.1.
Final NOAEL: 0.125 mg/kg/d

Compound: Aroclor 1016
Form: not applicable
Reference: Aulerich and Ringer 1980
Test Species: Mink
Body weight: 1.0 kg (EPA 1993)
food consumption: 0.137 kg/d (Bleavins and Aulerich 1981)
Exposure Duration: 18 months (>1 yr and during a critical lifestage = chronic).
Endpoint: reproduction
Exposure Route: oral in diet
Dosage: three dose levels:
2, 10, and 25 ppm; 10 ppm = NOAEL
Calculations:

$$\left[\frac{10 mg\ Aroclor\ 1016}{kg\ food} x \frac{137 g\ food}{day} x \frac{1 kg}{1000 g}\right] / 1\ kg\ BW = 1.37\ mg/kg/d$$

Comments: While kit mortality was greater for all dose levels, these differences were not significant. Because Aroclor 1016 at 25 ppm in the diet reduced kit growth, and the study considered exposure over 18 months including critical lifestages (reproduction), the

10 ppm dose was considered to be a chronic NOAEL.

Final NOAEL: 1.37 mg/kg/d

Compound: Aroclor 1242

Form: not applicable

Reference: Bleavins et al. 1980

Test Species: Mink

Body weight: 1.0 kg (EPA 1993)

food consumption: 0.137 kg/d (Bleavins and Aulerich 1981)

Exposure Duration: 7 months (during a critical lifestage = chronic).

Endpoint: reproduction

Exposure Route: oral in diet

Dosage: four dose levels:

5, 10, 20, and 40 ppm; 5 ppm = LOAEL

Calculations:

$$\left[\frac{5mg\ Aroclor\ 1254}{kg\ food}\ x\ \frac{137g\ food}{day}\ x\ \frac{1kg}{1000g}\right]\ /\ 1\ kg\ BW\ =\ 0.685\ mg/kg/d$$

Comments: Because all Aroclor 1242 dose levels produced total reproductive failure, and the study considered exposure over 7 months including critical lifestages (reproduction), the lowest dose was considered to be a chronic LOAEL. A chronic NOAEL was estimated by multiplying the chronic LOAEL by a LOAEL-NOAEL uncertainty factor of 0.1.

Final NOAEL: 0.0685 mg/kg/d

Compound: Aroclor 1242

Form: not applicable

Reference: McLane and Hughes 1980

Test Species: Screech Owl

Body weight: 0.181 kg (Dunning 1984)

food consumption: 1300-1700 g/month/pair (Pattee et al. 1988)

Daily food consumption was estimated as follows:

median food consumption/month/pair = 1500 g;

1 month = 30 d;

Males and females consume equal amounts of food = 750 g/month

750 g/month ÷ 30 d = 25 g/ d

Exposure Duration: 2 generations(during a critical lifestage = chronic).

Endpoint: reproduction

Exposure Route: oral in diet

Dosage: one dose level:

3 ppm = NOAEL

Calculations:

$$\left[\frac{3mg\ Aroclor1242}{kg\ food}\ x\ \frac{25g\ food}{day}\ x\ \frac{1kg}{1000g}\right]\ /\ 0.181\ kg\ BW\ =\ 0.41\ mg/kg/d$$

Comments: Fertility and hatching success was not significantly reduced by 3 ppm Aroclor 1242 in the diet. Because the study considered exposure during reproduction, this dose was considered to be a chronic NOAEL.

Final NOAEL: 0.41 mg/kg/d

Compound: Aroclor 1248
Form: not applicable
Reference: Barsotti et al. 1976
Test Species: Rhesus Monkey
Body weight: 5.0 kg (from study)
food consumption: 0.2 kg/d (EPA 1988a)
Exposure Duration: 14 months (>1 yr and during a critical lifestage = chronic).
Endpoint: reproduction
Exposure Route: oral in diet
Dosage: two dose levels:
2.5 and 5 ppm; 2.5 ppm = LOAEL
Calculations:

$$\left[\frac{2.5mg\ Aroclor\ 1248}{kg\ food}\ x\ \frac{200g\ food}{day}\ x\ \frac{1kg}{1000g}\right]\ /\ 5\ kg\ BW\ =\ 0.1\ mg/kg/d$$

Comments: Pregnancy and live birth rates were reduced by both dose levels. Because the study considered exposure over 14 months including critical lifestages (reproduction), the 2.5 ppm dose was considered to be a chronic LOAEL. A chronic NOAEL was estimated by multiplying the chronic LOAEL by a LOAEL-NOAEL uncertainty factor of 0.1.

Final NOAEL: 0.01 mg/kg/d

Compound: Aroclor 1254
Form: not applicable
Reference: Dahlgren et al. 1972
Test Species: Ring-necked Pheasant
Body weight: 1 kg (EPA 1993e)
Exposure Duration: 17 weeks (>10 wks and during a critical lifestage = chronic).
Endpoint: reproduction
Exposure Route: weekly oral dose via gelatin capsule

Dosage: two dose levels:
12.5 and 50 mg/bird/week; LOAEL = 12.5 mg/bird/week

Calculations: 12.5 mg/bird/week = 1.8 mg/kg/d

Comments: Significantly reduced egg hatchability was observed in both treatment groups. Therefore, because the study considered exposure throughout a critical lifestage (reproduction), the 12.5 mg/bird/week dose was considered to be a chronic LOAEL.

Final NOAEL: 0.18 mg/kg/d

Compound: Aroclor 1254
Form: not applicable
Reference: Linzey 1987
Test Species: White-footed mouse
Body weight: 0.02 kg (from study)
food consumption (from study): 0.135 g food/g BW/d or 2.7 g/animal/d
Exposure Duration: 18 months (>1 yr and during a critical lifestage = chronic).
Endpoint: reproduction
Exposure Route: oral in diet
Dosage: one dose level:
10 ppm = LOAEL
Calculations:

$$\left[\frac{10mg\ Aroclor\ 1254}{kg\ food} x \frac{2.7g\ food}{day} x \frac{1kg}{1000g}\right] / 0.02\ kg\ BW = 1.35\ mg/kg/d$$

Comments: Because Aroclor 1254 at 10 ppm in the diet reduced the number of offspring per litter and the study considered exposure over 18 months including critical lifestages (reproduction), this dose was considered to be a chronic LOAEL. A chronic NOAEL was estimated by multiplying the chronic LOAEL by a LOAEL-NOAEL uncertainty factor of 0.1.

Final NOAEL: 0.135 mg/kg/d

Compound: Aroclor 1254
Form: not applicable
Reference: Aulerich and Ringer 1977
Test Species: Mink
Body weight: 1.0 kg (EPA 1993e)
food consumption: 0.137 kg/d (Bleavins and Aulerich 1981)
Exposure Duration: 4.5 month (during a critical lifestage = chronic).
Endpoint: reproduction
Exposure Route: oral in diet
Dosage: three dose levels:
1, 5, and 15 ppm; NOAEL = 1 ppm.

Calculations:

$$\left[\frac{1mg\ Aroclor\ 1254}{kg\ food} \ x\ \frac{137g\ food}{day}\ x\ \frac{1kg}{1000g}\right] \ /\ 1\ kg\ BW = 0.137\ mg/kg/d$$

Comments: Because Aroclor 1254 at 5 and 15 ppm in the diet reduced the number of offspring born alive and the study considered exposure over 4.5 months days including critical lifestages (reproduction), the 1 ppm dose was considered to be a chronic NOAEL.

Final NOAEL: 0.137 mg/kg/d

Compound: Arsenic

Form: Arsenite (As^{+3})

Reference: Schroeder and Mitchner 1971

Test Species: Mouse

Body weight: 0.03 kg (EPA 1988a)

Water Consumption: 0.0075 L/d

Food Consumption: 0.0055 kg/d

(calculated using allometric equation from EPA 1988a)

Exposure Duration: 3 generations (> 1 yr and during critical lifestage=chronic)

Endpoint: reproduction

Exposure Route: oral in water (+ incidental in food; As species not stated, assumed to be As^{+3})

Dosage: one dose level:

5 mg As/L (in water) + 0.06 mg/kg As (in food) = LOAEL

Calculations:

$$\left[\frac{5mg\ As^{+3}}{L\ water}\ x\ \frac{7.5mL\ water}{day}\ x\ \frac{1L}{1000mL}\right] \ /\ 0.03\ kg\ BW = 1.25\ mg/kg/d$$

$$\left[\frac{0.06mg\ As^{+3}}{kg\ food}\ x\ \frac{5.5g\ food}{day}\ x\ \frac{1kg}{1000g}\right] \ /\ 0.03\ kg\ BW = 0.011\ mg/kg/d$$

Total Exposure = 1.25 mg/kg/d + 0.011 mg/kg/d = 1.261 mg/kg/d

Comments: Because mice exposed to As^{+3} displayed declining litter sizes with each successive generation and the study considered exposure over 3 generations, this dose was considered to be a chronic LOAEL. A chronic NOAEL was estimated by multiplying the chronic LOAEL by a LOAEL-NOAEL uncertainty factor of 0.1.

Final NOAEL: 0.126 mg/kg/d

Compound: Arsenic

Form: Paris Green; Copper Acetoarsenite (44.34% As^{+3})

Reference: USFWS 1969

Test Species: Brown-headed Cowbird (Males only)

Body weight: 0.049 kg (Dunning 1984)

Food Consumption: 0.01087 kg/d

(calculated using allometric equation from Nagy 1987)

Exposure Duration: 7 months (> 10 wk=chronic)

Endpoint: mortality

Exposure Route: oral in diet

Dosage: four dose level:

25, 75, 225, and 675 ppm Paris Green; NOAEL = 25 ppm

mg/kg As^{+3} = 0.4434 x 25 mg/kg = 11.09 mg/kg

Calculations:

$$\left[\frac{11.09\,mg\ As^{+3}}{kg\ food}\ x\ \frac{10.87\,g\ food}{day}\ x\ \frac{1\,kg}{1000\,g}\right]\ /\ 0.049\ kg\ BW = 2.46\ mg/kg/d$$

Comments: Cowbirds in the 675 and 225 ppm groups experienced 100% mortality. Those in the 75 and 25 ppm groups experienced 20% and 0% mortality, respectively. Because the study considered exposure over 7 months, the 25 ppm Paris green (11.09 mg/kg As^{+3}) dose was considered to be a chronic NOAEL.

Final NOAEL: 2.46 mg/kg/d

Compound: Arsenic

Form: Sodium Arsenite (51.35% As^{+3})

Reference: USFWS 1964

Test Species: Mallard Ducks

Body weight: 1 kg (Heinz et al. 1989)

Food Consumption: 0.100 kg/d (Heinz et al. 1989)

Exposure Duration: 128 d (> 10 wk=chronic)

Endpoint: mortality

Exposure Route: oral in diet

Dosage: four dose level:

100, 250, 500, and 1000 ppm Sodium Arsenite;

NOAEL = 100 ppm

mg/kg As^{+3} = 0.5135 x 100 mg/kg = 51.35 mg/kg

Calculations:

$$\left[\frac{51.35\,mg\ As^{+3}}{kg\ food}\ x\ \frac{100\,g\ food}{day}\ x\ \frac{1\,kg}{1000\,g}\right]\ /\ 1\ kg\ BW = 5.135\ mg/kg/d$$

Comments: Mallards in the 1000, 500, and 250 ppm groups experienced 92%, 60%, and 12% mortality, respectively. Because those in the 100 ppm group experienced 0% mortality, and the study considered exposure over 128 days, the 100 ppm Sodium Arsenite (11.09 mg/kg As^{+3}) dose was considered to be a chronic NOAEL.

Final NOAEL: 5.135 mg/kg/d

Compound: Barium
Form: Barium Chloride
Reference: Perry et al. 1983
Test Species: Rat
Body weight: 0.435 kg (from study)
Water Consumption: 0.022 L/d (from study)
Exposure Duration: 16 months (> 1yr = chronic)
Endpoint: growth, hypertension
Exposure Route: oral in water
Dosage: three dose level:
1, 10, and 100, ppm Ba (as Barium Chloride);
NOAEL = 100 ppm

Calculations:

$$\left[\frac{100\,mg\ Ba}{L\ water}\ x\ \frac{22\,mL\ water}{day}\ x\ \frac{1\,L}{1000\,mL}\right]\ /\ 0.435\ kg\ BW = 5.06\ mg/kg/d$$

Comments: While none of the three dose levels had any affect on food or water consumption or on growth, cardiovascular hypertension was observed among rats exposed to 10 or 100 ppm Ba. Because the significance of hypertension in wild populations is unclear, the maximum dose that did not affect growth, food or water consumption (100 ppm) was considered to be a chronic NOAEL.

Final NOAEL: 5.06 mg/kg/d

Compound: Barium
Form: Barium Hydroxide
Reference: Johnson et al. 1960
Test Species: 1-day old chicks
Body weight: 0.121 kg ($mean_{♂+♀}$ at 14 d; EPA 1988a)
Food Consumption: 0.0126 kg/d (calculated using allometric equation from EPA 1988a)
Exposure Duration: 4 wk (< 10 wk = subchronic)
Endpoint: mortality
Exposure Route: oral in diet

Dosage: eight dose level:
250, 500, 1000, 2000, 4000, 8000, 16000, and 32000 ppm
Ba (as Barium Hydroxide)
NOAEL = 2000 ppm

Calculations:

$$\left[\frac{2000\,mg\ Ba}{kg\ food} \; x \; \frac{12.6\,g\ food}{day} \; x \; \frac{1\,kg}{1000\,g}\right] \,/\, 0.121\ kg\ BW = 208.26\ mg/kg/d$$

Comments: To estimate daily Ba intake throughout the 4 week study period, food consumption of 2-week-old chicks was calculated. While this value will over- and underestimate food consumption by younger and older chicks, it was assumed to approximate food consumption throughout the entire 4 week study. While Barium exposures up to 2000 ppm produced no mortality, chicks in the 4000 to 32000 ppm groups experienced 5% to 100% mortality. Because 2000 ppm was the highest nonlethal dose, this dose was considered to be a subchronic NOAEL. A chronic NOAEL was estimated by multiplying the subchronic NOAEL by a subchronic to chronic uncertainty factor of 0.1.

Final NOAEL: 20.826 mg/kg/d

Compound: Benzene
Form: not applicable
Reference: Nawrot and Staples 1979
Test Species: Mouse
Body weight: 0.03 kg (EPA 1988a)
Exposure Duration: days 6-12 of gestation
(during a critical lifestage = chronic).
Endpoint: reproduction
Exposure Route: oral gavage
Dosage: three dose levels:
0.3, 0.5, and 1 mL/kg/d; LOAEL = 0.3 mL/kg/d
Calculations: density of benzene=0.8787 g/mL (Merck 1976)

$$\left[\frac{0.3\,mL\ Benzene}{kg\ BW} \; x \; \frac{0.8787\,g\ Benzene}{mL\ Benzene} \; x \; \frac{1000\,mg}{1\,g}\right] = 263.6\ mg/kg/d$$

Comments: Benzene exposure of 0.5 and 1.0 mL/kg/d significantly increased maternal mortality and embryonic resorption. Fetal weights were significantly reduced by all three dose levels. While the benzene exposures evaluated in this study were of a short duration, they occurred during a critical lifestage. Therefore, the 0.3 mL/kg/d dose was considered to be a chronic LOAEL. A chronic NOAEL was estimated by multiplying the chronic LOAEL by a LOAEL-NOAEL uncertainty factor of 0.1.

Final NOAEL: 26.36 mg/kg/d

Compound: β-Benzene Hexachloride (β-BHC)
Form: not applicable
Reference: Van Velsen et al. 1986
Test Species: Rat
Body weight: 0.35 kg (EPA 1988a)
Food Consumption: 0.028 kg/d (calculated using allometric equation from EPA 1988a)
Exposure Duration: 13 weeks
(< 1 yr and not during a critical lifestage = subchronic).
Endpoint: growth, blood chemistry, organ histology
Exposure Route: oral in diet
Dosage: four dose levels:
2, 10, 50, and 250 ppm; NOAEL = 50 ppm
Calculations:

$$\left[\frac{50\,mg\ \beta\text{-}BHC}{kg\ food}\ x\ \frac{28\,g\ food}{day}\ x\ \frac{1\,kg}{1000\,g}\right]\ /\ 0.35\ kg\ BW\ =\ 4\ mg/kg/d$$

Comments: Consumption of 250 ppm β-BHC in the diet caused gonadal atrophy in both male and female rats. Because no significant effects were observed in groups consuming 50 ppm β-BHC or less, this dose was considered to be a subchronic NOAEL. A chronic NOAEL was estimated by multiplying the subchronic NOAEL by a subchronic-chronic uncertainty factor of 0.1.
Final NOAEL: 0.4 mg/kg/d

Compound: Benzene Hexachloride (BHC mixed isomers)
Form: not applicable
Reference: Bleavins et al. 1984
Test Species: Mink
Body weight: 1.0 kg (EPA 1993e)
food consumption: 0.137 kg/d (Bleavins and Aulerich 1981)
Exposure Duration: 331 d (during a critical lifestage = chronic).
Endpoint: reproduction
Exposure Route: oral in diet
Dosage: three dose levels:
1, 5, and 25 ppm; 1 ppm = LOAEL
Calculations:

$$\left[\frac{1\,mg\ BHC}{kg\ food}\ x\ \frac{137\,g\ food}{day}\ x\ \frac{1\,kg}{1000\,g}\right]\ /\ 1\ kg\ BW\ =\ 0.137\ mg/kg/d$$

Comments: All dose levels produced increased kit mortality and decreased kit body weight. Because the study considered exposure over 331 days including critical lifestages (reproduction), this dose was considered to be a chronic LOAEL. A chronic NOAEL was estimated by multiplying the chronic LOAEL by a LOAEL-NOAEL uncertainty factor of 0.1.

Final NOAEL: 0.0137 mg/kg/d

Compound: Benzene Hexachloride (BHC mixed isomers)
Form: not applicable
Reference: Grant et al. 1977
Test Species: Rat
Body weight: 0.35 kg (EPA 1988a)
Food Consumption: 0.028 kg/d (calculated using allometric equation from EPA 1988a)
Exposure Duration: 4 generations (>1 yr and during a critical lifestage = chronic).
Endpoint: reproduction
Exposure Route: oral in diet
Dosage: seven dose levels:
10, 20, 40, 80, 160, 320, and 640 ppm; NOAEL = 20 ppm
Calculations:

$$\left[\frac{20 mg\ BHC}{kg\ food} \ x\ \frac{28 g\ food}{day} \ x\ \frac{1 kg}{1000 g}\right] \ / \ 0.35\ kg\ BW = 1.6\ mg/kg/d$$

Comments: Consumption of 320 ppm and 640 ppm BHC in the diet increased maternal mortality, 80 - 640 ppm BHC reduced litter sizes, and 40 - 320 ppm BHC reduced birthweights. Because no significant effects were observed in groups consuming 10 or 20 ppm BHC in their diet and the study considered exposure throughout four generations including critical lifestages (reproduction), the 20 ppm dose was considered to be a chronic NOAEL.

Final NOAEL: 1.6 mg/kg/d

Compound: Benzene Hexachloride (BHC mixed isomers)
Form: not applicable
Reference: Vos et al. 1971
Test Species: Japanese Quail
Body weight: 0.150 kg (from study)
Food Consumption: 0.0169 kg/d (calculated using allometric equation from Nagy 1987)
Exposure Duration: 90 d (during a critical lifestage = chronic).
Endpoint: reproduction

Exposure Route: oral in diet
Dosage: seven dose levels:
1, 5, 20, and 80 ppm; NOAEL = 5 ppm
Calculations:

$$\left(\frac{5mg\ BHC}{kg\ food}\ x\ \frac{16.9g\ food}{day}\ x\ \frac{1kg}{1000g}\right)\ /\ 0.15\ kg\ BW\ =\ 0.563\ mg/kg/d$$

Comments: Consumption of 20 ppm and 80 ppm BHC in the diet reduced egg hatchability and egg volume. Because no significant effects were observed in groups consuming 1 or 5 ppm BHC in their diet and the study considered exposure throughout a critical lifestage (reproduction), the 5 ppm dose was considered to be a chronic NOAEL.
Final NOAEL: 0.563 mg/kg/d

Compound: Benzo(a)pyrene (BaP)
Form: not applicable
Reference: Mackenzie and Angevine 1981
Test Species: Mouse
Body weight: 0.03 kg (EPA 1988a)
Exposure Duration: days 7-16 of gestation (during a critical lifestage = chronic).
Endpoint: reproduction
Exposure Route: oral intubation
Dosage: three dose levels:
10, 40, and 160 mg/kg/d; LOAEL = 10 mg/kg/d
Calculations: not applicable
Comments: BaP exposure 160 mg/kg/d significantly reduced pregnancy rates and percentage of viable litters. Pup weights were significantly reduced by all three dose levels. Total sterility was observed in 97% of offspring in the 40 and 160 mg/kg/d groups and fertility was impaired among offspring in the 10 mg/kg/d group. While the BaP exposures evaluated in this study were of a short duration, they occurred during a critical lifestage. Therefore, the 10 mg/kg/d dose was considered to be a chronic LOAEL. A chronic NOAEL was estimated by multiplying the chronic LOAEL by a LOAEL-NOAEL uncertainty factor of 0.1.
Final NOAEL: 1 mg/kg/d

Compound: Beryllium
Form: Beryllium Sulfate
Reference: Schroeder and Mitchner 1975

Test Species: Rat

Body weight: 0.35 kg (EPA 1988a)

Water Consumption: 0.046 L/d (calculated using allometric equation from EPA 1988a)

Exposure Duration: lifetime (> 1yr = chronic)

Endpoint: longevity, weight loss

Exposure Route: oral in water

Dosage: one dose level:
5 ppm Be = NOAEL

Calculations:

$$\left[\frac{5mg\ Be}{L\ water}\ x\ \frac{46mL\ water}{day}\ x\ \frac{1L}{1000mL}\right]\ /\ 0.35\ kg\ BW = 0.66\ mg/kg/d$$

Comments: While exposure to 5 ppm Be in water did not reduce longevity, weight loss by males was observed in months 2 - 6. Because the weight loss was not considered to be an adverse effect, the 5 ppm dose level was considered to be a chronic NOAEL.

Final NOAEL: 0.66 mg/kg/d

Compound: Bis(2-ethylhexyl)Phthalate (BEHP)

Form: not applicable

Reference: Lamb et al. 1987

Test Species: Mouse

Body weight: 0.03 kg (EPA 1988a)

Food Consumption: 0.0055 kg/d
(calculated using allometric equation from EPA 1988a)

Exposure Duration: 105 d (during critical lifestage = chronic).

Endpoint: reproduction

Exposure Route: oral in diet

Dosage: three dose levels:
0.01%, 0.1% and 0.3% of diet;
NOAEL = 0.01% = 100 mg/kg

Calculations:

$$\left[\frac{100mg\ BEHP}{kg\ food}\ x\ \frac{5.5g\ food}{day}\ x\ \frac{1kg}{1000g}\right]\ /\ 0.03\ kg\ BW = 18.33\ mg/kg/d$$

Comments: While significant reproductive effects were observed among mice on diets containing 0.1% and 0.3% Bis(2-ethylhexyl)Phthalate, no adverse effects were observed among the 0.01% dose group. Because the study considered exposure during critical lifestage, the 0.01% dose was considered to be a chronic NOAEL.

Final NOAEL: 18.33 mg/kg/d

Compound: Bis(2-ethylhexyl)Phthalate (BEHP)
Form: not applicable
Reference: Peakall 1974
Test Species: Ringed Dove
Body weight: 0.155 kg (Terres 1980)
Food Consumption: 0.01727 kg/d (calculated using allometric equation from Nagy 1987)
Exposure Duration: 4 weeks (during critical lifestage = chronic).
Endpoint: reproduction
Exposure Route: oral in diet
Dosage: one dose level:
10 ppm = NOAEL
Calculations:

$$\left[\frac{10mg\ BEHP}{kg\ food} \times \frac{17.27g\ food}{day} \times \frac{1kg}{1000g}\right] / 0.155\ kg\ BW = 1.11\ mg/kg/d$$

Comments: No significant reproductive effects were observed among doves on diets containing 10 ppm Bis(2-ethylhexyl)Phthalate, and the study considered exposure over 4 weeks and during a critical lifestage, the 10 ppm dose was considered to be a chronic NOAEL. .
Final NOAEL: 1.11 mg/kg/d

Compound: Cadmium
Form: soluble salt
Reference: Schroeder and Mitchner 1971
Test Species: Mouse
Body weight: 0.03 kg (EPA 1988a)
Water Consumption: 0.0075 L/d
Food Consumption: 0.0055 kg/d
(calculated using allometric equation from EPA 1988a)
Exposure Duration: 2 generations (>1 yr and during a critical lifestage = chronic).
Endpoint: reproduction
Exposure Route: oral in water (+incidental in food)
Dosage: one dose level:
10 ppm Cd (in water) + 0.1 ppm Cd (in food) = LOAEL

Calculations:

$$\left[\frac{10mg\ Cd}{L\ water} \ x\ \frac{7.5mL\ water}{day} \ x\ \frac{1L}{1000mL}\right] \ /\ 0.03\ kg\ BW = 2.5\ mg/kg/d$$

$$\left[\frac{0.1mg\ Cd}{kg\ food} \ x\ \frac{5.5g\ food}{day} \ x\ \frac{1kg}{1000g}\right] \ /\ 0.03\ kg\ BW = 0.018\ mg/kg/d$$

Total Exposure = 2.5 mg/kg/d + 0.018 mg/kg/d = 2.518 mg/kg/d

Comments: Because mice exposed to Cd displayed reduced reproductive success (the strain did not survive to the third generation) and congenital deformities, this dose was considered to be a chronic LOAEL. A chronic NOAEL was estimated by multiplying the chronic LOAEL by a LOAEL-NOAEL uncertainty factor of 0.1.

Final NOAEL: 0.1913 mg/kg/d

Compound: Cadmium
Form: Cadmium Chloride
Reference: White and Finley 1978
Test Species: Mallard Ducks
Body weight: 1.153 kg (from study)
Food Consumption: 0.110 kg/d (from study)
Exposure Duration: 90 d (> 10 wk and during a critical lifestage =chronic)
Endpoint: reproduction
Exposure Route: oral in diet
Dosage: three dose level:
1.6, 15.2, and 210 ppm Cd
NOAEL = 15.2 ppm
Calculations:

$$\left[\frac{15.2mg\ Cd}{kg\ food} \ x\ \frac{110g\ food}{day} \ x\ \frac{1kg}{1000g}\right] \ /\ 1.153\ kg\ BW = 1.45\ mg/kg/d$$

Comments: Mallards in the 210 ppm group produced significantly fewer eggs than those in the other groups. Because the study considered exposure over 90 days, the 15.2 ppm Cd dose was considered to be a chronic NOAEL.

Final NOAEL: 1.45 mg/kg/d

Compound: Carbon Tetrachloride
Form: not applicable
Reference: Alumot at al. 1976a

Test Species: Rat
Body weight: 0.35 kg (EPA 1988a)
Food Consumption: 0.028 kg/d (calculated using allometric equation from EPA 1988a)
Exposure Duration: 2 yr (>1 yr and during a critical lifestage = chronic).
Endpoint: reproduction
Exposure Route: oral in diet
Dosage: two dose levels:
80 and 200 ppm;
No effects observed at either dose level.
Calculations:

$$\left[\frac{200 mg\ CCl_4}{kg\ food} \ x\ \frac{28 g\ food}{day} \ x\ \frac{1 kg}{1000 g}\right] /\ 0.35\ kg\ BW = 16\ mg/kg/d$$

Comments: Because no significant differences were observed at either dose level and the study considered exposure throughout 2 years including critical lifestages (reproduction), the maximum dose was considered to be a chronic NOAEL.

Final NOAEL: 16 mg/kg/d

Compound: Chlordane
Form: not applicable
Reference: WHO 1984 (secondary source; Primary citation: Keplinger, M.L., W.B. Deichman, and F. Sala. 1968. Effects of pesticides on reproduction in mice. Ind. Med. Surg. 37: 525.)
Test Species: Mouse
Body weight: 0.03 kg (EPA 1988a)
Food Consumption: 0.0055 kg/d
(calculated using allometric equation from EPA 1988a)
Exposure Duration: 6 generations (>1 yr and during a critical lifestage = chronic).
Endpoint: reproduction
Exposure Route: oral in diet
Dosage: three dose levels:
25, 50, and 100 mg/kg; NOAEL = 25 mg/kg
Calculations:

$$\left[\frac{25 mg\ Chlordane}{kg\ food} \ x\ \frac{5.5 g\ food}{day} \ x\ \frac{1 kg}{1000 g}\right] /\ 0.03\ kg\ BW = 4.58\ mg/kg/d$$

Comments: While significant effects were observed among mice on diets containing 50 and 100 mg/kg Chlordane (decreased viability and reduced abundance of offspring), no adverse effects were observed among the 25 mg/kg dose group. Because the study considered exposure over six generations and through reproduction, the 25 mg/kg dose was considered to be a chronic NOAEL.

Final NOAEL: 4.58 mg/kg/d

Compound: Chlordane
Form: not applicable
Reference: Stickel et al. 1983
Test Species: Red-winged Blackbird
Body weight: 0.064 kg (from study)
Food Consumption: 0.0137 kg/d
(calculated using allometric equation from Nagy 1987)
Exposure Duration: 84 days (>10 weeks = chronic).
Endpoint: mortality
Exposure Route: oral in diet
Dosage: three dose levels:
10, 50, and 100 ppm; NOAEL = 10 ppm
Calculations:

$$\left[\frac{10mg\ Chlordane}{kg\ food} \times \frac{13.7g\ food}{day} \times \frac{1kg}{1000g}\right] / \ 0.064\ kg\ BW = 2.14\ mg/kg/d$$

Comments: While 26% and 24% mortality was observed among birds on diets containing 50 and 100 mg/kg Chlordane, no adverse effects were observed among the 10 mg/kg dose group. Because the study considered exposure over 84 days, the 10 mg/kg dose was considered to be a chronic NOAEL.

Final NOAEL: 2.14 mg/kg/d

Compound: Chlordecone (Kepone)
Form: not applicable
Reference: Larson et al. 1979
Test Species: Rat
Body weight: 0.35 kg (EPA 1988a)
Food Consumption: 0.028 kg/d (calculated using allometric equation from EPA 1988a)
Exposure Duration: 2 yr (>1 yr and during a critical lifestage = chronic).
Endpoint: mortality, growth, kidney damage
Exposure Route: oral in diet
Dosage: five dose levels:
1, 5, 10, 25, and 80 ppm; NOAEL = 1 ppm

Calculations:

$$\left[\frac{1mg\ Chlordecone}{kg\ food} \ x\ \frac{28g\ food}{day}\ x\ \frac{1kg}{1000g}\right] \ /\ 0.35\ kg\ BW\ =\ 0.08\ mg/kg/d$$

Comments: Chlordecone at 25 and 80 ppm in the diet produced 100% mortality in 6 months. Growth was depressed by 10 and 25 ppm and kidney damage was observed at doses as low as 5 ppm. Because the study considered exposure throughout 2 years, the 1 ppm dose was considered to be a chronic NOAEL.

Final NOAEL: 0.08 mg/kg/d

Compound: Chloroform
Form: not applicable
Reference: Palmer et al. 1979
Test Species: Rat
Body weight: 0.35 kg (EPA 1988a)
Exposure Duration: 13 wk (<1 yr and not during a critical lifestage = subchronic).
Endpoint: liver, kidney, gonad condition
Exposure Route: oral intubation
Dosage: four dose levels:
15, 30, 150, and 410 mg/kg/d; NOAEL = 150 mg/kg/d
Calculations: not applicable

Comments: Gonadal atrophy was observed among male and female rats receiving 410 mg/kg/d; therefore 150 mg/kg/d was considered to be a subchronic NOAEL. To estimate the chronic NOAEL, the subchronic NOAEL was multiplied by a subchronic-chronic uncertainty factor of 0.1.

Final NOAEL: 15 mg/kg/d

Compound: Chromium
Form: Cr^{+3} as Cr_2O_3 (68.42% Cr)
Reference: Ivankovic and Preussmann 1975
Test Species: Rat
Body weight: 0.35 kg (EPA 1988a)
Food Consumption: 0.028 kg/d (calculated using allometric equation from EPA 1988a)
Exposure Duration: 90 d and 2 yr
Endpoint: reproduction, longevity
Exposure Route: oral in diet
Dosage: three dose levels:
Cr_2O_3 as 1%, 2% or 5% of diet
No effects observed at any dose level

Calculations:

$$\left[\frac{50{,}000\,mg\ Cr_2O_3}{kg\ food} \times \frac{28\,g\ food}{day} \times \frac{1\,kg}{1000\,g}\right] / 0.35\ kg\ BW = 4000\ mg/kg/d$$

0.6842 x 4000 mg Cr_2O_3 /kg/d or 2737 mg Cr^{+3}/kg/d.

Comments: Reproductive effects were evaluated among rats fed 2% or 5% Cr_2O_3 for 90 d; carcinogenicity and longevity were evaluated among rats fed 1%, 2% or 5% Cr_2O_3 for 2 years. Because no significant differences were observed at any dose level in either study and both studies considered exposure throughout 2 years or a critical lifestage (reproduction), the maximum dose was considered to be a chronic NOAEL.

Final NOAEL: 2737 mg/kg/d

Compound: Chromium
Form: Cr^{+6} as $K_2Cr_2O_4$
Reference: MacKenzie et al. 1958
Test Species: Rat
Body weight: 0.35 kg (EPA 1988a)
Water Consumption: 0.046 L/d (calculated using allometric equation from EPA 1988a)
Exposure Duration: 1 yr
Endpoint: body weight and food consumption
Exposure Route: oral in water
Dosage: six dose levels:
0.45, 2.2, 4.5, 7.7, 11.2, and 25 ppm Cr^{+6} in diet
No effects observed at any dose level

Calculations:

$$\left[\frac{25\,mg\ Cr^{+6}}{L\ water} \times \frac{0.046\,L\ water}{day}\right] / 0.35\ kg\ BW = 3.28\ mg/kg/d$$

Comments: Because no significant differences were observed at any dose level studied and the study considered exposure over 1 year, the maximum dose was considered to be a chronic NOAEL.

Final NOAEL: 3.28 mg/kg/d

Compound: Chromium
Form: Cr^{+3} as $CrK(SO_4)_2$
Reference: Haseltine et al. , unpubl. data

Test Species: Black duck

Body weight: 1.25 kg (mean$_{♂+♀}$; Dunning 1984)

Food Consumption: Congeneric Mallard ducks, weighing 1 kg consume 100 g food/d (Heinz et al.1989). Therefore, it was assumed that a 1.25 kg black duck would consume 125 g food/d.

Exposure Duration: 10 mo. (> 10 weeks and during a critical lifestage = chronic).

Endpoint: reproduction

Exposure Route: oral in diet

Dosage: two dose levels:
10 and 50 ppm Cr^{+3} in diet; NOAEL = 10 ppm

Calculations:

$$\left[\frac{10mg\ Cr^{+3}}{kg\ food}\ x\ \frac{125g\ food}{day}\ x\ \frac{1kg}{1000g}\right]\ /\ 1.25\ kg\ BW = 1\ mg/kg/d$$

Comments: Because no significant differences were observed at the 10 ppm Cr^{+3} dose level and the study considered exposure throughout a critical lifestage (reproduction), this dose was considered to be a chronic NOAEL.

Final NOAEL: 1 mg/kg/d

Compound: Copper

Form: Copper Sulfate

Reference: Aulerich et al. 1982

Test Species: Mink

Body weight: 1.0 kg (EPA 1993e)

food consumption: 0.137 kg/d (Bleavins and Aulerich 1981)

Exposure Duration: 357 d (during a critical lifestage = chronic).

Endpoint: reproduction

Exposure Route: oral in diet

Dosage: four dose levels:
25, 50, 100, and 200 ppm Cu supplemental + 60.5 ppm Cu in base feed; NOAEL = 85.5 ppm Cu (supplement + base)

Calculations:

$$\left[\frac{85.5mg\ Cu}{kg\ food}\ x\ \frac{137g\ food}{day}\ x\ \frac{1kg}{1000g}\right]\ /\ 1\ kg\ BW = 11.71\ mg/kg/d$$

Comments: Consumption of 50, 100, and 200 ppm supplemental Cu increased the percentage mortality of mink kits. Kit survivorship among the 25 ppm supplemental Cu group was actual greater than the controls. Because this study was approximately one year in duration and considered exposure during reproduction, the 25 ppm supplemental Cu (85.5 ppm total Cu) dose was considered to be a chronic NOAEL.

Final NOAEL: 11.71 mg/kg/d

Compound: Copper
Form: Copper Oxide
Reference: Mehring et al. 1960
Test Species: 1 day old chicks
Body weight: 0.534 kg (mean$_{♂+♀}$ at 5 weeks; EPA 1988a)
food consumption: 0.044 kg/d (calculated using allometric equation from EPA 1988a)
Exposure Duration: 10 weeks (10 weeks = chronic).
Endpoint: growth
Exposure Route: oral in diet
Dosage: eleven dose levels:
36.8, 52.0, 73.5, 104.0, 147.1, 208.0, 294.1, 403, 570, 749, and 1180 ppm total Cu; NOAEL = 403 ppm total Cu
Calculations:

$$\left[\frac{403\,mg\ Cu}{kg\ food}\ x\ \frac{44\,g\ food}{day}\ x\ \frac{1\,kg}{1000\,g}\right]\ /\ 0.534\ kg\ BW\ =\ 33.21\ mg/kg/d$$

Comments: Consumption of Cu up to 403 ppm had no effect of growth of chicks. Because this study was 10 weeks in duration, the 403 ppm Cu dose was considered to be a chronic NOAEL. To estimate daily Cu intake throughout the 10 week study period, food consumption of 5-week-old chicks was calculated. While this value will over- and underestimate food consumption by younger and older chicks, it was assumed to approximate food consumption throughout the entire 10 week study.
Final NOAEL: 33.21 mg/kg/d

Compound: *o*-Cresol
Form: not applicable
Reference: Hornshaw et al. 1986
Test Species: Mink
Body weight: 1.0 kg (EPA 1993e)
food consumption: 0.137 kg/d (Bleavins and Aulerich 1981)
Exposure Duration: 6 months (during a critical lifestage = chronic).
Endpoint: reproduction
Exposure Route: oral in diet
Dosage: three dose levels:
100, 400, and 1600 ppm ; NOAEL = 1600 ppm
Calculations:

$$\left[\frac{1600\,mg\ o\text{-}Cresol}{kg\ food}\ x\ \frac{137\,g\ food}{day}\ x\ \frac{1\,kg}{1000\,g}\right]\ /\ 1\ kg\ BW\ =\ 216.2\ mg/kg/d$$

Comments: No adverse effects were observed at any dose level. Because this study considered exposure during reproduction, the maximum dose was considered to be a chronic NOAEL.

Final NOAEL: 216.2 mg/kg/d

Compound: Cyanide
Form: Potassium Cyanide
Reference: Tewe and Maner 1981
Test Species: Rat
Body weight: 0.273 kg (from study)
Food Consumption: 0.0375 kg/d (from study)
Exposure Duration: gestation and lactation (during a critical lifestage = chronic).
Endpoint: reproduction
Exposure Route: oral in diet
Dosage: one dose level:
500 ppm CN = LOAEL
No effects observed at either dose level.
Calculations:

$$\left[\frac{500mg\ CN}{kg\ food}\ x\ \frac{37.5g\ food}{day}\ x\ \frac{1kg}{1000g}\right]\ /\ 0.273\ kg\ BW\ =\ 68.7\ mg/kg/d$$

Comments: Because consumption of 500 ppm CN reduced offspring growth and the study considered exposure throughout a critical lifestage (reproduction), this dose was considered to be a chronic LOAEL. To estimate the chronic NOAEL, the chronic NOAEL was multiplied by a LOAEL-NOAEL uncertainty factor of 0.1.

Final NOAEL: 6.87 mg/kg/d

Compound: DDT
Form: not applicable
Reference: Fitzhugh 1948
Test Species: Rat
Body weight: 0.35 kg (EPA 1988a)
Food Consumption: 0.028 kg/d (calculated using allometric equation from EPA 1988a)
Exposure Duration: 2 yr (> 1 yr and during a critical lifestage = chronic)
Endpoint: reproduction,
Exposure Route: oral in diet
Dosage: four dose levels:
10, 50, 100, and 600 ppm; NOAEL = 10 ppm

Calculations:

$$\left[\frac{10mg\ DDT}{kg\ food}\ x\ \frac{28g\ food}{day}\ x\ \frac{1kg}{1000g}\right]\ /\ 0.35\ kg\ BW\ =\ 0.8\ mg/kg/d$$

Comments: While consumption of 50 ppm or more DDT in the diet reduced the number of young produced, no adverse effects were observed at the 10 ppm DDT dose level. Because the study considered exposure throughout 2 years and reproduction, the 10 ppm DDT dose was considered to be a chronic NOAEL.

Final NOAEL: 0.8 mg/kg/d

Compound: DDT
Form: not applicable
Reference: Anderson et al. 1975
Test Species: Brown Pelican
Body weight: 3.5 kg (Dunning 1984)
Food Consumption: 0.66 kg/d (EPA 1993e)
Exposure Duration: 5 yr (> 1 yr and during a critical lifestage = chronic)
Endpoint: reproduction,
Exposure Route: oral in diet
Dosage: one dose level:
0.15 ppm DDT; LOAEL = 0.15 ppm

Calculations:

$$\left[\frac{0.15mg\ DDT}{kg\ food}\ x\ \frac{660g\ food}{day}\ x\ \frac{1kg}{1000g}\right]\ /\ 3.5\ kg\ BW\ =\ 0.0028\ mg/kg/d$$

Comments: Anderson et al. (1975) studied the reproductive success of pelicans from 1969 through 1974. During this time, DDT residues in anchovies, their primary food, declined from 4.27 ppm (wet weight) to 0.15 ppm (wet weight). While reproductive success improved from 1969 to 1974, in 1974 the fledgling rate was still 30% below that needed to maintain a stable population. Because this study was long-term and considered reproductive effects in a wildlife species, EPA (1993) judged this study to be the most appropriate to evaluate DDT effects to avian wildlife. Therefore the 0.15 ppm DDT value was considered to be a chronic LOAEL. To estimate the chronic NOAEL, the chronic NOAEL was multiplied by a LOAEL-NOAEL uncertainty factor of 0.1.

Final NOAEL: 0.00028 mg/kg/d

Compound: 1,2,-Dichloroethane
Form: not applicable
Reference: Lane et al. 1982

Test Species: Mouse
Body weight: 0.035 kg (from study)
Water Consumption: 6 mL/d (from study)
Exposure Duration: 2 generations (>1 yr and during a critical lifestage = chronic).
Endpoint: reproduction
Exposure Route: oral in water
Dosage: three dose levels:
5, 15, and 50 mg/kg/d
No effects observed at any dose level.
Calculations: not applicable
Comments: Because no significant differences were observed at any dose level and the study considered exposure throughout 2 generations including critical lifestages (reproduction), the maximum dose was considered to be a chronic NOAEL.
Final NOAEL: 50 mg/kg/d.

Compound: 1,2,-Dichloroethane
Form: not applicable
Reference: Alumot at al. 1976b
Test Species: Chicken
Body weight: 1.6 kg (mean$_{♂+♀}$ from study)
Food Consumption: 0.11 kg/d (calculated using allometric equation from EPA 1988a)
Exposure Duration: 2 yr (>10 wk and during a critical lifestage = chronic).
Endpoint: reproduction
Exposure Route: oral in diet
Dosage: two dose levels:
250 and 500 ppm; NOAEL = 250 ppm
Calculations:

$$\left[\frac{250 mg\ 1{,}2 Dichloroethane}{kg\ food} \times \frac{0.11 kg\ food}{day}\right] / 1.6\ kg\ BW = 17.2\ mg/kg/d$$

Comments: Because no significant differences were observed at the 250 ppm dose level and the study considered exposure throughout 2 years including critical lifestages (reproduction), this dose was considered to be a chronic NOAEL.
Final NOAEL: 17.2 mg/kg/d

Compound: 1,1-Dichloroethylene
Form: not applicable
Reference: Quast et al. 1983
Test Species: Rat
Body weight: 0.35 kg (EPA 1988a)

Exposure Duration: 2 years (> 1 yr = chronic).
Endpoint: mortality, body weight, blood chemistry, liver histology
Exposure Route: oral in water
Dosage: three dose levels:
7, 10, and 20 mg/kg/d (males) and
9, 14, and 30 mg/kg/d (females); NOAEL = 30 mg/kg/d
Calculations: not applicable

Comments: The only treatment-related effect observed were microscopic hepatic lesions. These were evident among females at all dose levels and among males only at the highest dose level. No other treatment effects were observed. Because the relationship of hepatic lesions to potential population effects is unknown and no other effects were observed, the maximum dose, 30 mg/kg/d was considered a chronic NOAEL.

Final NOAEL: 30 mg/kg/d

Compound: 1,1-Dichloroethylene
Form: not applicable
Reference: Quast et al. 1983
Test Species: dog (beagle)
Body weight: 10 kg (EPA 1988a)
Exposure Duration: 97 d (< 1 yr and not during a critical lifestage = subchronic).
Endpoint: mortality, body weight, blood chemistry, liver histology
Exposure Route: daily oral capsules
Dosage: three dose levels:
6.25, 12.5, and 25 mg/kg/d; NOAEL = 25 mg/kg/d
Calculations: not applicable

Comments: No adverse effects were observed among any of the treatments, therefore the maximum dose, 25 mg/kg/d was considered a subchronic NOAEL. A chronic NOAEL was estimated by multiplying the subchronic NOAEL by a subchronic-chronic uncertainty factor of 0.1.

Final NOAEL: 2.5 mg/kg/d

Compound: 1,2-Dichloroethylene
Form: not applicable
Reference: Palmer et al. 1979
Test Species: Mouse
Body weight: 0.03 kg (EPA 1988a)
Exposure Duration: 90 d (< 1 yr and not during a critical lifestage = subchronic).
Endpoint: body and organ weights, blood chemistry, hepatic function
Exposure Route: oral in water

Dosage: three dose levels:
16.8, 175, and 387 mg/kg/d (Males)
22.6, 224, and 452 mg/kg/d (Females)
NOAEL = 452 mg/kg/d

Calculations: not applicable

Comments: Exposure to 387 mg/kg/d 1,2-Dichloroethylene reduced glutathione levels in males and all dose levels reduced aniline hydroxylase activity in females. No other treatment effects were observed. Because the relationship of enzyme levels to potential population effects is unknown and no other effects were observed, the maximum dose, 452 mg/kg/d was considered a subchronic NOAEL. To estimate the chronic NOAEL, the subchronic NOAEL was multiplied by a subchronic-chronic uncertainty factor of 0.1.

Final NOAEL: 45.2 mg/kg/d

Compound: Dieldrin
Form: not applicable
Reference: Treon and Cleveland 1955
Test Species: Rat
Body weight: 0.35 kg (EPA 1988a)
Food Consumption: 0.028 kg/d (calculated using allometric equation from EPA 1988a)
Exposure Duration: 3 generations (>1 yr and during a critical lifestage = chronic).
Endpoint: reproduction
Exposure Route: oral in diet
Dosage: three dose levels:
2.5, 12.5, and 25.0 ppm; LOAEL = 2.5 ppm

Calculations:

$$\left[\frac{2.5\,mg\ Dieldrin}{kg\ food}\ x\ \frac{28\,g\ food}{day}\ x\ \frac{1\,kg}{1000\,g}\right]\ /\ 0.35\ kg\ BW\ =\ 0.2\ mg/kg/d$$

Comments: Because Dieldrin at 2.5 ppm in the diet reduced the number of pregnancies in rats and the study considered exposure throughout 3 generations including critical lifestages (reproduction), this dose was considered to be a chronic LOAEL. A chronic NOAEL was estimated by multiplying the chronic LOAEL by a LOAEL-NOAEL uncertainty factor of 0.1.

Final NOAEL: 0.02 mg/kg/d

Compound: Dieldrin
Form: not applicable
Reference: Mendenhall et al. 1983

Test Species: Barn Owl
Body weight (BW): 0.466 kg (mean$_{♂+♀}$; Johnsgard 1988)
Food Consumption: wild birds 100-150 g/d ; 50-75 g/d captive (Johnsgard 1988). Used median captive food consumption value: 62.5 g/d
Exposure Duration: 2 yrs (>10 weeks and during a critical lifestage = chronic).
Endpoint: reproduction
Exposure Route: oral in diet
Dosage: Only 1 dose level applied: 0.58 ppm NOAEL
Calculations:

$$\left[\frac{0.58\,mg\ Dieldrin}{kg\ food}\ x\ \frac{62.5\,g\ food}{day}\ x\ \frac{1\,kg}{1000\,g}\right]\ /\ 0.466\ kg\ BW\ =\ 0.077\ mg/kg/d$$

Comments: While 0.58 ppm Dieldrin in the diet produced a slight but significant reduction in eggshell thickness, no significant effect on no. eggs laid/pair, no. eggs hatched/pair, % eggs broken, embryo or nestling mortality was observed. Therefore this dose was considered to be a chronic NOAEL.
Final NOAEL: 0.077 mg/kg/d

Compound: Diethylphthalate (DEP)
Form: not applicable
Reference: Lamb et al. 1987
Test Species: Mouse
Body weight: 0.03 kg (EPA 1988a)
Food Consumption: 0.0055 kg/d
(calculated using allometric equation from EPA 1988a)
Exposure Duration: 105 d (during a critical lifestage = chronic).
Endpoint: reproduction
Exposure Route: oral in diet
Dosage: three dose levels:
0.25%, 1.25% and 2.5% of diet;
NOAEL = 2.5% = 25000 mg/kg
Calculations:

$$\left[\frac{25000\,mg\ DEP}{kg\ food}\ x\ \frac{5.5\,g\ food}{day}\ x\ \frac{1\,kg}{1000\,g}\right]\ /\ 0.03\ kg\ BW\ =\ 4583\ mg/kg/d$$

Comments: No significant reproductive effects were observed among mice in any of the treatment groups. Because the study considered exposure during a critical lifestage, the maximum dose was considered to be a chronic NOAEL.
Final NOAEL: 4583 mg/kg/d

Compound: Di-n-butyl phthalate (DBP)
Form: not applicable
Reference: Lamb et al. 1987
Test Species: Mouse
Body weight: 0.03 kg (EPA 1988a)
Food Consumption: 0.0055 kg/d
(calculated using allometric equation from EPA 1988a)
Exposure Duration: 105 d (during a critical lifestage = chronic).
Endpoint: reproduction
Exposure Route: oral in diet
Dosage: three dose levels:
0.03%, 0.3% and 1% of diet;
NOAEL = 0.3% = 3000 mg/kg
Calculations:

$$\left[\frac{3000 mg\ DBP}{kg\ food} x \frac{5.5 g\ food}{day} x \frac{1 kg}{1000 g}\right] / 0.03\ kg\ BW = 550\ mg/kg/d$$

Comments: While significant reproductive effects were observed among mice on diet containing 1% DBP, no adverse effects were observed among either the 0.03% or 0.3% dose groups. Because the study considered exposure during a critical lifestage, the 0.3% dose was considered to be a chronic NOAEL.
Final NOAEL: 550 mg/kg/d

Compound: Di-n-butyl phthalate (DBP)
Form: not applicable
Reference: Peakall 1974
Test Species: Ringed Dove
Body weight: 0.155 kg (Terres 1980)
Food Consumption: 0.01727 kg/d (calculated using allometric equation from Nagy 1987)
Exposure Duration: 4 weeks (during a critical lifestage = chronic).
Endpoint: reproduction
Exposure Route: oral in diet
Dosage: one dose level:
10 ppm = LOAEL
Calculations:

$$\left[\frac{10 mg\ DBP}{kg\ food} x \frac{17.27 g\ food}{day} x \frac{1 kg}{1000 g}\right] / 0.155\ kg\ BW = 1.11\ mg/kg/d$$

Comments: Eggshell thickness and water permeability of the shell was reduced among doves on diets containing 10 ppm DBP. Because the study considered exposure during a critical lifestage the 10 ppm dose was considered to be a chronic LOAEL. A chronic NOAEL was estimated by multiplying the chronic LOAEL by a LOAEL-NOAEL uncertainty factor of 0.1.

Final NOAEL: 0.111 mg/kg/d

Compound: Di-n-hexylphthalate (DHP)
Form: not applicable
Reference: Lamb et al. 1987
Test Species: Mouse
Body weight: 0.03 kg (EPA 1988a)
Food Consumption: 0.0055 kg/d
(calculated using allometric equation from EPA 1988a)
Exposure Duration: 105 d (during a critical lifestage = chronic)..
Endpoint: reproduction
Exposure Route: oral in diet
Dosage: three dose levels:
0.3%, 0.6% and 1.2% of diet;
LOAEL = 0.3% = 3000 mg/kg
Calculations:

$$\left[\frac{3000mg\ DHP}{kg\ food}\ x\ \frac{5.5g\ food}{day}\ x\ \frac{1kg}{1000g}\right]\ /\ 0.03\ kg\ BW = 550\ mg/kg/d$$

Comments: Significant reproductive effects were observed among mice on all diets. Because the study considered exposure during a critical lifestage, the 0.3% dose was considered to be a chronic LOAEL. A chronic NOAEL was estimated by multiplying the chronic LOAEL by a LOAEL-NOAEL uncertainty factor of 0.1.

Final NOAEL: 55 mg/kg/d

Compound: 1,4-Dioxane
Form: not applicable
Reference: Giavini et al. 1985
Test Species: rat
Body weight: 0.35 kg (EPA 1988a)
Exposure Duration: days 6-15 of gestation (during a critical lifestage = chronic).
Endpoint: reproduction
Exposure Route: oral intubation
Dosage: three dose levels:
0.25, 0.5, and 1.0 mg/kg/d; NOAEL = 0.5 mg/kg/d
Calculations: not applicable

Comments: Maternal toxicity and reduced fetal weights were observed among rats receiving the 1.0 mg/kg/d dose. No adverse effects were observed among the other treatments. Because the study considered exposure during a critical lifestage, the 0.5 mg/kg/d was considered to be a chronic NOAEL.

Final NOAEL: 0.5 mg/kg/d

Compound: Endosulfan
Form: not applicable
Reference: Dikshith et al. 1984
Test Species: Rat
Body weight: 0.35 kg (EPA 1988a)
Food Consumption: 0.028 kg/d (calculated using allometric equation from EPA 1988a)
Exposure Duration: 30 days
(< 1 yr and not during a critical lifestage = subchronic).
Endpoint: reproduction, blood chemistry
Exposure Route: oral intubation
Dosage: three dose levels per sex:
male: 0.75, 2.5, and 5.0 mg/kg/d
female 0.25, 0.75, and 1.5 mg/kg/d
Calculations: not applicable

Comments: Male and female rats were dosed for 30 days at the three respective dose levels, then one male and two females from the following groups were paired and allowed to mate: 5 mg/kg/d (♂) x 0 mg/kg/d (control♀) and 0 mg/kg/d (control ♂) x 1.5 mg/kg/d (♀). No adverse effects were observed for any dose level. Because it was assumed that adverse reproductive effects were more likely to be observed in exposed females than males, and because the study was < 1 yr in duration and did not include a critical lifestage (exposure was discontinued prior to gestation), the 1.5 mg/kg/d dose was considered a subchronic NOAEL. A chronic NOAEL was estimated by multiplying the subchronic NOAEL by a subchronic-chronic uncertainty factor of 0.1.

Final NOAEL: 0.15 mg/kg/d

Compound: Endosulfan
Form: not applicable
Reference: Abiola 1992
Test Species: Gray Partridge
Body weight: 0.400 kg (from study)
Food Consumption: 0.032 kg/d (calculated using allometric equation from Nagy 1987)
Exposure Duration: 4 weeks (during a critical lifestage = chronic).
Endpoint: reproduction
Exposure Route: oral in diet

Dosage: three dose levels:
5, 25, 125 ppm; NOAEL = 125 ppm

Calculations:

$$\left[\frac{125\,mg\ Endosulfan}{kg\ food} \times \frac{32\,g\ food}{day} \times \frac{1\,kg}{1000\,g}\right] / \ 0.400\ kg\ BW = 10\ mg/kg/d$$

Comments: No adverse effects were observed at any dose level. Because exposure occurred during reproduction, the maximum dose was considered a chronic NOAEL.

Final NOAEL: 10 mg/kg/d

Compound: Endrin
Form: not applicable
Reference: Good and Ware 1969
Test Species: Mouse
Body weight: 0.03 kg (EPA 1988a)
Food Consumption: 0.0055 kg/d
(calculated using allometric equation from EPA 1988a)
Exposure Duration: 120 d (during a critical lifestage = chronic)..
Endpoint: reproduction
Exposure Route: oral in diet
Dosage: one dose level:
5 ppm = LOAEL

Calculations:

$$\left[\frac{5\,mg\ Endrin}{kg\ food} \times \frac{5.5\,g\ food}{day} \times \frac{1\,kg}{1000\,g}\right] / \ 0.03\ kg\ BW = 0.92\ mg/kg/d$$

Comments: Significant reproductive effects (reduced parental survival, litter size, and number of young/d) were observed among mice fed diets containing 5 ppm Endrin. Because the study considered exposure during a critical lifestage, this dose was considered to be a chronic LOAEL. A chronic NOAEL was estimated by multiplying the chronic LOAEL by a LOAEL-NOAEL uncertainty factor of 0.1.

Final NOAEL: 0.092 mg/kg/d

Compound: Endrin
Form: not applicable
Reference: Spann et al. 1986
Test Species: Mallard duck
Body weight: 1.15 kg (from study)
Food Consumption: Mallard ducks, weighing 1 kg consume 100 g food/d (Heinz et al.1989). Therefore, it was assumed that a 1.15 kg Mallard duck would consume 115 g food/d.

Exposure Duration: >200 d. (>10 weeks and during a critical lifestage = chronic).
Endpoint: reproduction
Exposure Route: oral in diet
Dosage: two dose levels:
1 and 3 ppm Endrin in diet; NOAEL = 3 ppm
Calculations:

$$\left[\frac{3mg\ Endrin}{kg\ food} \ x\ \frac{115g\ food}{day} \ x\ \frac{1kg}{1000g}\right] \ /\ 1.15\ kg\ BW = 0.3\ mg/kg/d$$

Comments: While the authors state that birds receiving the 3 ppm dose appeared to reproduce more poorly than controls, this difference was not significant. Because no significant differences were observed at the 3 ppm dose level and the study considered exposure throughout a critical lifestage (reproduction), this dose was considered to be a chronic NOAEL.

Final NOAEL: 0.3 mg/kg/d

Compound: Ethanol
Form: not applicable
Reference: Mankes et al. 1982
Test Species: Rat
Body weight: 0.35 kg (EPA 1988a)
Exposure Duration: through gestation (during a critical lifestage = chronic).
Endpoint: reproduction
Exposure Route: oral intubation
Dosage: two dose levels: 0.4 and 4.0 ml/kg/d; LOAEL=0.4 ml/kg/d
Calculations: density of ethanol=0.798 g/mL (Merck 1976)

$$\left[\frac{0.4mL\ Ethanol}{kg\ BW} \ x\ \frac{0.798g\ Ethanol}{mL\ Ethanol} \ x\ \frac{1000mg}{1g}\right] = 319\ mg/kg/d$$

Comments: While 0.4 ml Ethanol/kg/d had no effect on most reproductive parameters, the incidence of malformed fetuses was significantly increased at this dose level. Therefore this dose was considered to be a chronic LOAEL. To estimate the chronic NOAEL, the LOAEL was multiplied by a LOAEL-NOAEL uncertainty factor of 0.1.

Final NOAEL: 31.9 mg/kg/d

Compound: Ethyl Acetate
Form: not applicable
Reference: EPA 1986d
Test Species: Rat
Body weight: 0.35 kg (EPA 1988a)

Exposure Duration: 90 days (< 1 yr and not during a critical lifestage=subchronic).
Endpoint: mortality and weight loss
Exposure Route: oral intubation
Dosage: three dose levels:
300, 900, and 3600 mg/kg/d; NOAEL = 900 mg/kg/d
Calculations: not applicable

Comments: While Ethyl Acetate at 3600 mg/kg/d reduced body and organ weights and food consumption by male rats, no effects were observed at the 900 mg/kg/d dose level. Because the study was 90 days in duration and did not consider exposure during critical lifestages, the 900 mg/kg/d dose was considered to be a chronic LOAEL. A chronic NOAEL was estimated by multiplying the chronic LOAEL by a LOAEL-NOAEL uncertainty factor of 0.1.

Final NOAEL: 90 mg/kg/d

Compound: Fluoride
Form: NaF
Reference: Aulerich et al. 1987
Test Species: Mink
Body weight: 1.0 kg (EPA 1993e)
food consumption: 0.137 kg/d (Bleavins and Aulerich 1981)
Exposure Duration: 382 d (during a critical lifestage = chronic).
Endpoint: reproduction
Exposure Route: oral in diet
Dosage: five dose levels:
33, 60, 108, 194, and 350 ppm supplemental F + 35 ppm F in base diet; NOAEL = 194 ppm + 35 ppm = 229 ppm F
Calculations:

$$\left[\frac{229\,mg\ F}{kg\ food} \times \frac{137\,g\ food}{day} \times \frac{1\,kg}{1000\,g}\right] /\ 1\ kg\ BW = 31.37\ mg/kg/d$$

Comments: Fluoride up to 229 ppm in mink diets had no adverse effects on reproduction; Survivorship of kits in the 385 ppm (350+35 ppm) group was significantly reduced. Because 229 ppm F in the diet had no adverse effect and the study considered exposure over 382 days including critical lifestages (reproduction), this dose was considered to be a chronic NOAEL.

Final NOAEL: 31.37 mg/kg/d

Compound: Fluoride
Form: NaF
Reference: Pattee et al. 1988

Test Species: Screech Owl
Body weight: 0.181 kg (Dunning 1984)
food consumption: 1300-1700 g/month/pair (from study)
Daily food consumption was estimated as follows:
median food consumption/month/pair = 1500 g;
1 month = 30 d;
Males and females consume equal amounts of food = 750 g/month
750 g/month ÷ 30 d = 25 g/ d

Exposure Duration: 5-6 months (during a critical lifestage = chronic).
Endpoint: reproduction
Exposure Route: oral in diet
Dosage: two dose levels:
56.5 and 232 ppm F; NOAEL = 56.5 ppm F
Calculations:

$$\left[\frac{56.5\,mg\ F}{kg\ food}\ x\ \frac{25\,g\ food}{day}\ x\ \frac{1\,kg}{1000\,g}\right]\ /\ 0.181\ kg\ BW = 7.8\ mg/kg/d$$

Comments: Fertility and hatching success was significantly reduced by 232 ppm F in the diet. Because 56.5 ppm F in the diet had no adverse effect and the study considered exposure during reproduction, this dose was considered to be a chronic NOAEL.
Final NOAEL: 7.8 mg/kg/d

Compound: Formaldehyde
Form: not applicable
Reference: Hurni and Ohder 1973
Test Species: dog (beagle)
Body weight: 12 kg (from study)
Exposure Duration: through gestation and lactation
(during a critical lifestage = chronic).
Endpoint: reproduction
Exposure Route: oral in diet
Dosage: two dose levels:
3.1 and 9.4 mg/kg/d; NOAEL = 9.4 mg/kg/d
Calculations: not applicable
Comments: Because significant effects were not observed at any dose level, the 9.4 mg/kg/d was considered to be a chronic NOAEL.
Final NOAEL: 9.4 mg/kg/d

Compound: Heptachlor
Form: not applicable
Reference: Eisler 1968

Test Species: Rat
Body weight: 0.35 kg (EPA 1988a)
Food Consumption: 0.028 kg/d (calculated using allometric equation from EPA 1988a)
Exposure Duration: 3 generations (>1 yr and during a critical lifestage = chronic).
Endpoint: reproduction
Exposure Route: oral in diet
Dosage: four dose levels:
0.3, 3, 6, and 10 ppm; NOAEL = 10 ppm
Calculations:

$$\left[\frac{10mg\ Heptachlor}{kg\ food} x \frac{28g\ food}{day} x \frac{1kg}{1000g}\right] / 0.35\ kg\ BW = 0.8\ mg/kg/d$$

Comments: Because significant effects were not observed at any dose level, the 10 ppm was considered to be a chronic NOAEL.
Final NOAEL: 0.8 mg/kg/d

Compound: 1,2,3,6,7,8 - Hexachloro Dibenzofuran (HxDBF)
Form: not applicable
Reference: Poiger et al. 1989
Test Species: Rat
Body weight: 0.35 kg (EPA 1988a)
Food Consumption: 0.028 kg/d (calculated using allometric equation from EPA 1988a)
Exposure Duration: 13 weeks
(<1 yr and not during a critical lifestage = subchronic).
Endpoint: Body weight, organ weight, blood chemistry
Exposure Route: oral in diet
Dosage: three dose levels:
2, 20, and 200 ppb; NOAEL = 20 ppb
Calculations:

$$\left[\frac{0.02mg\ HxDBF}{kg\ food} x \frac{28g\ food}{day} x \frac{1kg}{1000g}\right] / 0.35\ kg\ BW = 0.0016\ mg/kg/d$$

Comments: Because rats exposed to 200 ppb HxDBF in the diet displayed reduced body, thymus and liver weights, while those in the 20 ppb group did not, the 20 ppb dose was considered to be a subchronic NOAEL. A chronic NOAEL was estimated by multiplying the subchronic NOAEL by a subchronic-chronic uncertainty factor of 0.1.
Final NOAEL: 0.00016 mg/kg/d

Compound: Lead
Form: Lead Acetate
Reference: Azar et al. 1973
Test Species: Rat
Body weight: 0.35 kg (EPA 1988a)
Food Consumption: 0.028 kg/d (calculated using allometric equation from EPA 1988a)
Exposure Duration: 3 generations (>1 yr and during a critical lifestage = chronic).
Endpoint: reproduction
Exposure Route: oral in diet
Dosage: five dose levels:
10, 50, 100, 1000, and 2000 ppm Pb; NOAEL = 100 ppm Pb
Calculations:

$$\left[\frac{100 mg\ Pb}{kg\ food} \ x\ \frac{28 g\ food}{day} \ x\ \frac{1 kg}{1000 g}\right] \ /\ 0.35\ kg\ BW\ =\ 8\ mg/kg/d$$

Comments: While none of the Pb exposure levels studied affected the number of pregnancies, the number of live births, or other reproductive indices, Pb exposure of 1000 and 2000 ppm resulted in reduced offspring weights and produced kidney damage in the young. Therefore the 100 ppm Pb dose was considered to be a chronic NOAEL.
Final NOAEL: 8 mg/kg/d

Compound: Lead
Form: Metallic
Reference: Pattee 1984
Test Species: American Kestrels
Body weight: 0.130 kg (mean$_{♂+♀}$; from study)
Food Consumption: Kenaga (1973) states that the congeneric European kestrel consumes 7.7% of body weight/d. Therefore, food consumption was assumed to be 0.077 x 0.130 kg or 0.01 kg/d.
Exposure Duration: 7 months (>10 weeks and during a critical lifestage = chronic).
Endpoint: reproduction
Exposure Route: oral in diet
Dosage: two dose levels:
10 and 50 ppm Pb; NOAEL = 50 ppm Pb
Calculations:

$$\left[\frac{50 mg\ Pb}{kg\ food} \ x\ \frac{10 g\ food}{day} \ x\ \frac{1 kg}{1000 g}\right] \ /\ 0.13\ kg\ BW\ =\ 3.85\ mg/kg/d$$

Comments: Because significant effects were not observed at either dose levels and the study considered exposure over 7 months and throughout a critical lifestage (reproduction), the maximum dose was considered to be a chronic NOAEL.

Final NOAEL: 3.85 mg/kg/d

Compound: Lindane (γ-BHC)

Form: not applicable

Reference: Palmer et al. 1978

Test Species: Rat

Body weight: 0.35 kg (EPA 1988a)

Food Consumption: 0.028 kg/d (calculated using allometric equation from EPA 1988a)

Exposure Duration: 3 generations (>1 yr and during a critical lifestage = chronic).

Endpoint: reproduction

Exposure Route: oral in diet

Dosage: three dose levels:

25, 50, and 100 ppm; NOAEL = 100 ppm

Calculations:

$$\left[\frac{100mg\ Lindane}{kg\ food}\ x\ \frac{28g\ food}{day}\ x\ \frac{1kg}{1000g}\right]\ /\ 0.35\ kg\ BW = 8\ mg/kg/d$$

Comments: Because significant effects were not observed at any dose level, the 100 ppm was considered to be a chronic NOAEL.

Final NOAEL: 8 mg/kg/d

Compound: Lindane (γ-BHC)

Form: not applicable

Reference: Chakravarty and Lahiri 1986; Chakravarty et al. 1986

Test Species: Mallard Duck

Body weight: 1.0 kg (Heinz et al. 1989)

Exposure Duration: 8 weeks (during a critical lifestage = chronic).

Endpoint: reproduction

Exposure Route: oral intubation

Dosage: one dose level:

20 mg/kg/d = LOAEL

Calculations: not applicable

Comments: Mallards exposed to 20 mg/kg/d displayed reduced eggshell thickness, laid fewer eggs and had longer time intervals between eggs. Because the study considered exposure during a critical lifestage, the 20 mg/kg/d was considered to be a chronic LOAEL. A chronic NOAEL was estimated by multiplying the chronic LOAEL by a LOAEL-NOAEL uncertainty factor of 0.1.

Final NOAEL: 2 mg/kg/d

Compound: Lithium
Form: Lithium Carbonate (18.78% Li)
Reference: Marathe and Thomas 1986
Test Species: Rat
Body weight: 0.35 kg (EPA 1988a)
Food Consumption: 0.028 kg/d (calculated using allometric equation from EPA 1988a)
Exposure Duration: days 6-15 of gestation (during a critical lifestage = chronic).
Endpoint: reproduction
Exposure Route: oral in diet
Dosage: two dose levels:
50 and 100 mg/kg/d Lithium Carbonate: NOAEL = 50 mg/kg/d
Calculations: mg Li /kg/d = 0.1878 x 50 mg/kg/d = 9.39

Comments: Lithium carbonate exposure of 100 mg/kg/d reduced the number of offspring and offspring weights. No adverse effects were observed at the 50 mg/kg level. While the Lithium exposures evaluated in this study were of a short duration, they occurred during a critical lifestage. Therefore, the 50 mg/kg/d dose was considered to be a chronic NOAEL.

Final NOAEL: 9.39 mg/kg/d

Compound: Manganese
Form: Manganese Oxide (Mn_3O_4)
Reference: Laskey et al. 1982
Test Species: Rat
Body weight: 0.35 kg (EPA 1988a)
Food Consumption: 0.028 kg/d (calculated using allometric equation from EPA 1988a)
Exposure Duration: through gestation for 224 d
(during a critical lifestage = chronic).
Endpoint: reproduction
Exposure Route: oral in diet
Dosage: three dose levels:
350, 1050, and 3500 ppm supplemented Mn + 50 ppm Mn in base diet; NOAEL = 1100 ppm
Calculations:

$$\left[\frac{1100 mg\ Mn}{kg\ food} x \frac{28 g\ food}{day} x \frac{1 kg}{1000 g}\right] / \ 0.35\ kg\ BW = 88\ mg/kg/d$$

Comments: While the pregnancy percentage and fertility among rats consuming 3550 ppm Mn in their diet was significantly reduced, all other reproductive parameters (e.g., litter size, ovulations, resorptions, preimplantation death, fetal weights) were not affected. No effects were observed at lower Mn exposure levels. Therefore the 1100 ppm Mn dose was considered to be a chronic NOAEL.

Final NOAEL: 88 mg/kg/d

Compound: Mercury
Form: Mercuric chloride
Reference: Knoflach et al. 1986
Test Species: Rat
Body weight: 0.03 kg (EPA 1988a)
Exposure Duration: 39 week
(< 1 yr and not during a critical lifestage = subchronic).
Endpoint: Immune system and kidney impairment
Exposure Route: oral intubation
Dosage: one dose level:
0.64 mg/kg/d = LOAEL
Calculations: not applicable

Comments: Because immune system and kidney function were impaired by the 0.64 mg/kg/d dose level and the study was less than one year in duration and did not consider exposure during critical lifestages, this dose was considered to be a subchronic LOAEL. A chronic NOAEL was estimated by multiplying the subchronic LOAEL by a LOAEL-NOAEL uncertainty factor of 0.1 and a subchronic-chronic uncertainty factor of 0.1.

Final NOAEL: 0.0064 mg/kg/d

Compound: Mercury
Form: Mercuric sulfide
Reference: Revis et al. 1989
Test Species: Mouse
Body weight: 0.03 kg (EPA 1988a)
Exposure Duration: 20 month (> 1 yr = chronic).
Endpoint: mortality, liver and kidney histology,
reproduction (6 month only)
Exposure Route: oral in diet
Dosage: 30 dose levels ranging up to 13.2 mg/kg/d
Calculations: not applicable

Comments: No adverse effects were observed at any dose level. Because the study was over one year in duration, the maximum dose 13.2 mg/kg/d was considered to be a chronic NOAEL.

Final NOAEL: 13.2 mg/kg/d

Compound: Mercury
Form: Methyl Mercury Chloride
Reference: Wobeser et al. 1976

Test Species: Mink
Body weight: 1 kg (EPA 1993e)
Food Consumption: 0.137 kg/d (Bleavins and Aulerich 1981)
Exposure Duration: 93 days
(<1 yr and not during a critical lifestage = subchronic).
Endpoint: mortality, weight loss, ataxia
Exposure Route: oral in diet
Dosage: five dose levels:
1.1, 1.8, 4.8, 8.3, and 15 ppm Hg as methyl mercury;
NOAEL = 1.1 ppm Hg
Calculations:

$$\left[\frac{1.1\,mg\ Hg}{kg\ food}\ x\ \frac{137\,g\ food}{day}\ x\ \frac{1\,kg}{1000\,g}\right]\ /\ 1\ kg\ BW = 0.15\ mg/kg/d$$

Comments: Mercury doses of 1.8 ppm or greater produced significant adverse effects (mortality, weight loss, behavioral abnormalities). Because significant effects were not observed at the 1.1 ppm Hg dose level, this dose was considered to be a subchronic NOAEL. A chronic NOAEL was estimated by multiplying the subchronic NOAEL by a subchronic-chronic uncertainty factor of 0.1
Final NOAEL: 0.015 mg/kg/d

Compound: Mercury
Form: Methyl Mercury Chloride (CH_3HgCl; 79.89% Hg)
Reference: Verschuuren et al. 1976
Test Species: Rat
Body weight: 0.35 kg (EPA 1988a)
Food Consumption: 0.028 kg/d (calculated using allometric equation from EPA 1988a)
Exposure Duration: 3 generations (>1 yr and during a critical lifestage = chronic).
Endpoint: reproduction
Exposure Route: oral in diet
Dosage: three dose levels:
0.1, 0.5, and 2.5 ppm Methyl Mercury Chloride;
NOAEL = 0.5 ppm Methyl Mercury Chloride
0.7989 x 0.5 mg/kg = 0.399 mg Hg /kg
Calculations:

$$\left[\frac{0.399\,mg\ Hg}{kg\ food}\ x\ \frac{28\,g\ food}{day}\ x\ \frac{1\,kg}{1000\,g}\right]\ /\ 0.35\ kg\ BW = 0.032\ mg/kg/d$$

Comments: While exposure to 2.5 ppm methyl mercury chloride reduced pup viability, adverse effects were not observed at lower doses. Because significant effects were not observed at the 0.5 ppm Methyl Mercury Chloride dose level, this dose was considered to be a chronic NOAEL.

Final NOAEL: 0.032 mg/kg/d

Compound: Mercury
Form: Methyl Mercury Dicyandiamide
Reference: Heinz 1979
Test Species: Mallard Duck
Body weight: 1 kg (Heinz et al. 1989)
Food Consumption: 0.128 kg/d (from study)
Exposure Duration: 3 generations (>1 yr and during a critical lifestage = chronic).
Endpoint: reproduction
Exposure Route: oral in diet
Dosage: one dose level:
0.5 ppm Hg as Methyl Mercury Dicyandiamide
LOAEL = 0.5 ppm
Calculations:

$$\left(\frac{0.5\,mg\ Hg}{kg\ food}\ x\ \frac{128\,g\ food}{day}\ x\ \frac{1\,kg}{1000\,g}\right)\ /\ 1\ kg\ BW = 0.064\ mg/kg/d$$

Comments: Because significant effects (fewer eggs and ducklings were produced) were observed at the 0.5 ppm Hg dose level and the study consider exposure over three generations, this dose was considered to be a chronic LOAEL. A chronic NOAEL was estimated by multiplying the chronic LOAEL by a LOAEL-NOAEL uncertainty factor of 0.1.

Final NOAEL: 0.0064 mg/kg/d

Compound: Methanol
Form: not applicable
Reference: EPA 1986e
Test Species: Rat
Body weight: 0.35 kg (EPA 1988a)
Exposure Duration: 90 days (<1 yr and not during a critical lifestage=subchronic).
Endpoint: mortality, blood chemistry
Exposure Route: oral intubation
Dosage: three dose levels:
100, 500, and 2500 mg/kg/d; NOAEL = 500 mg/kg/d
Calculations: not applicable

Comments: While Methanol at 2500 mg/kg/d reduced brain and liver weights and altered blood chemistry, no effects were observed at the 500 mg/kg/d dose level. Because the study was 90 days in duration and did not consider exposure during critical lifestages, the

500 mg/kg/d dose was considered to be a chronic LOAEL. A chronic NOAEL was estimated by multiplying the chronic LOAEL by a LOAEL-NOAEL uncertainty factor of 0.1.

Final NOAEL: 50 mg/kg/d

Compound: Methoxychlor
Form: not applicable
Reference: Gray et al. 1988
Test Species: Rat
Body weight: 0.35 kg (EPA 1988a)
Food Consumption: 0.028 kg/d (calculated using allometric equation from EPA 1988a)
Exposure Duration: 11 month (during a critical lifestage = chronic).
Endpoint: reproduction
Exposure Route: oral in diet
Dosage: four dose levels:
25, 50, 100 and 200 ppm; NOAEL = 50 ppm
Calculations:

$$\left[\frac{50\,mg\ Methoxychlor}{kg\ food}\ x\ \frac{28\,g\ food}{day}\ x\ \frac{1\,kg}{1000\,g}\right]\ /\ 0.35\ kg\ BW\ =\ 4\ mg/kg/d$$

Comments: Fertility and litter size was significantly reduced among rats fed diets containing 100 or 200 ppm methoxychlor. Because significant effects were not observed at the 50 ppm dose level and the study considered exposure during reproduction, the 50 ppm was considered to be a chronic NOAEL.

Final NOAEL: 4 mg/kg/d

Compound: Methylene Chloride
Form: not applicable
Reference: NCA 1982
Test Species: Rat
Body weight: 0.35 kg (EPA 1988a)
Exposure Duration: 2 yrs (>1 yr=chronic).
Endpoint: liver histology
Exposure Route: oral in water
Dosage: four dose levels:
5.85, 50, 125, and 250 mg/kg/d; NOAEL = 5 mg/kg/d
Calculations: not applicable

Comments: While Methylene Chloride at 50 mg/kg/d or greater produced histological changes in the liver, no effects were observed at the 5.85 mg/kg/d dose level.

Because the study was 2 yrs in duration, the 5.85 mg/kg/d dose was considered to be a chronic NOAEL.

Final NOAEL: 5.85 mg/kg/d

Compound: Methyl Ethyl Ketone
Form: not applicable
Reference: Cox et al. 1975
Test Species: Rat
Body weight: 0.35 kg (EPA 1988a)
Exposure Duration: 2 generations (> 1 yr and during a critical lifestage=chronic).
Endpoint: reproduction
Exposure Route: oral in water
Dosage: three dose levels:
538, 1644, and 5089 mg/kg/d (males),
594, 1771, and 4571 mg/kg/d (females);
NOAEL = 1771 mg/kg/d
Calculations: not applicable

Comments: While Methyl Ethyl Ketone at the highest dose levels reduced the number of pups/litter, pup survivorship, and pup body weight, no adverse effects were observed at the next higher levels (1644 mg/kg/d and 1771 mg/kg/d for males and females respectively). Because the study was 2 generations in duration, the 1771 mg/kg/d dose was considered to be a chronic NOAEL.

Final NOAEL: 1771 mg/kg/d

Compound: 4-Methyl 2-Pentanone (Methyl Isobutyl Ketone)
Form: not applicable
Reference: Microbiological Associates 1986 (obtained from Health Effects Assessment Summary Tables (HEAST; EPA 1993f)
Test Species: Rat
Body weight: 0.35 kg (EPA 1988a)
Exposure Duration: 13 weeks
(< 1 yr and not during a critical lifestage=subchronic).
Endpoint: Liver and kidney function
Exposure Route: oral gavage
Dosage: one dose level stated in HEAST summary:
250 mg/kg/d = NOAEL
Calculations: not applicable

Comments: Because the study was less than 1 year in duration and not considered exposure during a critical life stage, the 250 mg/kg/d dose was considered to be a subchronic NOAEL. A chronic NOAEL was estimated by multiplying the subchronic NOAEL by a subchronic-chronic uncertainty factor of 0.1

Final NOAEL: 25 mg/kg/d

Compound: Nickel
Form: Nickel Sulfate Hexahydrate
Reference: Ambrose et al. 1976
Test Species: Rat
Body weight: 0.35 kg (EPA 1988a)
Food Consumption: 0.028 kg/d (calculated using allometric equation from EPA 1988a)
Exposure Duration: 3 generations (>1 yr and during a critical lifestage = chronic).
Endpoint: reproduction
Exposure Route: oral in diet
Dosage: three dose levels:
250, 500, and 1000 ppm Ni
NOAEL = 500 ppm
Calculations:

$$\left[\frac{500 mg\ Ni}{kg\ food} x \frac{28 g\ food}{day} x \frac{1 kg}{1000 g}\right] / 0.35\ kg\ BW = 40\ mg/kg/d$$

Comments: While 1000 ppm Ni in the diet reduced offspring body weights, no adverse effects were observed in the other dose levels. Because this study considers exposures over multiple generations, the 500 ppm dose was considered to be a chronic NOAEL.
Final NOAEL: 40 mg/kg/d

Compound: Nickel
Form: Nickel Sulfate
Reference: Cain and Pafford 1981
Test Species: Mallard Duckling
Body weight: 0.782 kg (mean$_{control\ ♂+♀}$ at 45 days; from study)
Food Consumption: Adult Mallard ducks, weighing 1 kg consume 100 g food/d (Heinz et al.1989). Therefore, it was assumed that a 0.782 kg mallard duckling would consume 78.2 g food/d.
Exposure Duration: 90 d (>10 week = chronic).
Endpoint: mortality, growth, behavior
Exposure Route: oral in diet
Dosage: three dose levels:
176, 774, and 1069 ppm Ni;
NOAEL = 774 ppm

Calculations:

$$\left[\frac{774mg\ Ni}{kg\ food} \times \frac{78.2g\ food}{day} \times \frac{1kg}{1000g}\right] / 0.782\ kg\ BW = 77.4\ mg/kg/d$$

Comments: Consumption of up to 774 ppm Ni in diet did not increase mortality or reduce growth. Because the study considered exposure over 90 days, the 774 ppm dose was considered to be a chronic NOAEL To estimate daily Ni intake throughout the 90 day study period, food consumption of 45-day-old ducklings was calculated. While this value will over- and underestimate food consumption by younger and older ducklings, it was assumed to approximate food consumption throughout the entire 90 day study.

Final NOAEL: 77.4 mg/kg/d

Compound: Niobium
Form: Sodium niobate
Reference: Schroeder et al. 1968
Test Species: Mouse
Body weight: 0.03 kg (EPA 1988a)
Water Consumption: 0.0075 L/d
Food Consumption: 0.0055 kg/d
(calculated using allometric equation from EPA 1988a)
Exposure Duration: lifetime (>1 yr = chronic).
Endpoint: lifespan, longevity
Exposure Route: oral in water (+incidental in food)
Dosage: one dose level:
5 ppm Nb (in water) + 1.62 ppm Nb (in food) = LOAEL

Calculations:

$$\left[\frac{5mg\ Nb}{L\ water} \times \frac{7.5mL\ water}{day} \times \frac{1L}{1000mL}\right] / 0.03\ kg\ BW = 1.25\ mg/kg/d$$

$$\left[\frac{1.62mg\ Nb}{kg\ food} \times \frac{5.5g\ food}{day} \times \frac{1kg}{1000g}\right] / 0.03\ kg\ BW = 0.297\ mg/kg/d$$

Total Exposure = 1.25 mg/kg/d + 0.297 mg/kg/d = 1.547 mg/kg/d

Comments: Because median lifespan was reduced among female mice exposed to the 5 ppm dose level and the study considered exposure throughout the entire lifespan, this dose was considered to be a chronic LOAEL. A chronic NOAEL was estimated by multiplying the chronic LOAEL by a LOAEL-NOAEL uncertainty factor of 0.1.

Final NOAEL: 0.1166 mg/kg/d

Compound: Nitrate
Form: Potassium Nitrate
Reference: Sleight and Atallah 1968
Test Species: Guinea pig
Body weight: 0.86 kg (EPA 1988a)
Exposure Duration: 143-204 days (during a critical lifestage=chronic).
Endpoint: reproduction
Exposure Route: oral in water
Dosage: four dose levels:
12, 102, 507, and 1130 mg nitrate-Nitrogen kg/d;
NOAEL = 507 mg/kg/d
Calculations: not applicable

Comments: While Nitrate at the highest dose level reduced the number of live births, no adverse effects were observed at the other dose levels. Because the study considered exposure during reproduction, the 507 mg/kg/d dose was considered to be a chronic NOAEL.

Final NOAEL: 507 mg/kg/d

Compound: 1,2,3,4,8 - Pentachloro Dibenzofuran (PeDBF)
Form: not applicable
Reference: Poiger et al. 1989
Test Species: Rat
Body weight: 0.35 kg (EPA 1988a)
Food Consumption: 0.028 kg/d (calculated using allometric equation from EPA 1988a)
Exposure Duration: 13 weeks
(<1 yr and not during a critical lifestage = subchronic).
Endpoint: Body weight, organ weight, blood chemistry
Exposure Route: oral in diet
Dosage: two dose levels:
600 and 6000 ppb; NOAEL = 6000 ppb
Calculations:

$$\left[\frac{6mg\ PeDBF}{kg\ food} \ x\ \frac{28g\ food}{day} \ x\ \frac{1kg}{1000g} \right] \ /\ 0.35\ kg\ BW = 0.48\ mg/kg/d$$

Comments: Because no significant effects were observed at either dose level, the 6000 ppb dose was considered to be a subchronic NOAEL. A chronic NOAEL was estimated by multiplying the subchronic NOAEL by a subchronic-chronic uncertainty factor of 0.1.

Final NOAEL: 0.048 mg/kg/d

Compound: 1,2,3,7,8 - Pentachloro Dibenzofuran (PeDBF)

Form: not applicable

Reference: Poiger et al. 1989

Test Species: Rat

Body weight: 0.35 kg (EPA 1988a)

Food Consumption: 0.028 kg/d (calculated using allometric equation from EPA 1988a)

Exposure Duration: 13 weeks
(<1 yr and not during a critical lifestage = subchronic).

Endpoint: Body weight, organ weight, blood chemistry

Exposure Route: oral in diet

Dosage: three dose levels:
2, 20, and 200 ppb; NOAEL = 20 ppb

Calculations:

$$\left[\frac{0.02 mg\ HxDBF}{kg\ food} \ x\ \frac{28 g\ food}{day} \ x\ \frac{1 kg}{1000 g}\right] / \ 0.35\ kg\ BW = 0.0016\ mg/kg/d$$

Comments: Because rats exposed to 200 ppb PeDBF in the diet displayed reduced body, thymus weights, while those in the 20 ppb group did not, the 20 ppb dose was considered to be a subchronic NOAEL. A chronic NOAEL was estimated by multiplying the subchronic NOAEL by a subchronic-chronic uncertainty factor of 0.1.

Final NOAEL: 0.00016 mg/kg/d

Compound: 2,3,4,7,8 - Pentachloro Dibenzofuran (PeDBF)

Form: not applicable

Reference: Poiger et al. 1989

Test Species: Rat

Body weight: 0.35 kg (EPA 1988a)

Food Consumption: 0.028 kg/d (calculated using allometric equation from EPA 1988a)

Exposure Duration: 13 weeks
(<1 yr and not during a critical lifestage = subchronic).

Endpoint: Body weight, organ weight, blood chemistry

Exposure Route: oral in diet

Dosage: three dose levels:
2, 20, and 200 ppb; NOAEL = 2 ppb

Calculations:

$$\left[\frac{0.002 mg\ PeDBF}{kg\ food} \ x\ \frac{28 g\ food}{day} \ x\ \frac{1 kg}{1000 g}\right] / \ 0.35\ kg\ BW = 0.00016\ mg/kg/d$$

Comments: Because rats exposed to 20 and 200 ppb PeDBF in the diet displayed reduced body, thymus and liver weights, while those in the 2 ppb group did not, the 2 ppb dose was considered to be a subchronic NOAEL. A chronic NOAEL was estimated by multiplying the subchronic NOAEL by a subchronic-chronic uncertainty factor of 0.1.

Final NOAEL: 0.000016 mg/kg/d

Compound: Pentachloronitrobenzene (PCNB)

Form: not applicable

Reference: Dunn et al. 1979

Test Species: Chicken

Body weight: 1.5 kg (EPA 1988a)

Food Consumption: 0.106 kg/d (calculated using allometric equation from EPA 1988a)

Exposure Duration: 35 weeks

(> 10 weeks and during a critical lifestage = chronic).

Endpoint: reproduction

Exposure Route: oral in diet

Dosage: four dose levels:

10, 50, 100, and 1000 ppm; NOAEL = 100 ppm

Calculations:

$$\left(\frac{100 mg\ PCNB}{kg\ food} \ x\ \frac{106 g\ food}{day}\ x\ \frac{1 kg}{1000 g} \right) /\ 1.5\ kg\ BW\ =\ 7.07\ mg/kg/d$$

Comments: Onset on egg production and egg hatchability was reduced among birds receiving 1000 ppm PCNB. No adverse effects were observed among the other dose levels. Because the study considered exposure through reproduction, the 100 ppm dose was considered to be a chronic NOAEL.

Final NOAEL: 7.07 mg/kg/d

Compound: Selenium

Form: Selanate (SeO_4)

Reference: Schroeder and Mitchner 1971

Test Species: Mouse

Body weight: 0.03 kg (EPA 1988a)

Water Consumption: 0.0075 L/d

(calculated using allometric equation from EPA 1988a)

Exposure Duration: 3 generations (> 1 yr and during critical lifestage=chronic)

Endpoint: reproduction

Exposure Route: oral in water

Dosage: one dose level:

3 mg Se/L = LOAEL

Calculations:

$$\left[\frac{3mg\ Se}{L\ water}\ x\ \frac{7.5L\ water}{day}\ x\ \frac{1L}{1000mL}\right]\ /\ 0.03\ kg\ BW\ =\ 0.75mg/kg/d$$

Comments: Because mice exposed to Se displayed reduced reproductive success with a high incidence of runts and failure to breed, this dose was considered to be a chronic LOAEL. A chronic NOAEL was estimated by multiplying the chronic LOAEL by a LOAEL-NOAEL uncertainty factor of 0.1.

Final NOAEL: 0.075 mg/kg/d

Compound: Selenium
Form: Sodium Selanite
Reference: Heinz et al. 1987
Test Species: Mallard Duck
Body Weight: 1 kg (from study)
Food Consumption: 100 g/d (from study)
Exposure Duration: 78 days (>10 wks and during critical lifestage=chronic)
Endpoint: reproduction
Exposure Route: oral in diet
Dosage: five dose levels:
1, 5, 10, 25, and 100 ppm Se; 5 ppm = NOAEL
Calculations:

$$\left[\frac{5mg\ Se}{kg\ food}\ x\ \frac{100g\ food}{day}\ x\ \frac{1kg}{1000mg}\right]\ /\ 1\ kg\ BW\ =\ 0.5\ mg/kg/d$$

Comments: While consumption of 1, 5, or 10 ppm Se on the diet as Sodium Selanite had no effect on weight or survival of adults, 100 ppm Se reduced adult survival and 25 ppm Se reduced duckling survival. Consumption of 10 or 25 ppm Se in the diet resulted in a significantly larger frequency of lethally deformed embryos as compared to the 1 or 5 ppm Se exposures. Because 5 ppm Se in the diet was the highest dose level that produced no adverse effects and the study considered exposure through reproduction, this dose was considered to be a chronic NOAEL.

Final NOAEL: 0.5 mg/kg/d

Compound: Selenium
Form: Selanomethionine
Reference: Heinz et al. 1989
Test Species: Mallard Duck
Body Weight: 1 kg (from study)
Food Consumption: 100 g/d (from study)

Exposure Duration: 100 days (>10 wks and during critical lifestage=chronic)
Endpoint: reproduction
Exposure Route: oral in diet
Dosage: five dose levels:
1, 2, 4, 8, and 16 ppm Se; 5 ppm = NOAEL
Calculations:

$$\left[\frac{4mg\ Se}{kg\ food} x \frac{100g\ food}{day} x \frac{1kg}{1000mg}\right] / 1\ kg\ BW = 0.4\ mg/kg/d$$

Comments: Consumption of 8 or 16 ppm Se in the diet as Selanomethionine resulted in a reduced duckling survival as compared to the 1, 2, or 4 ppm Se exposures. Because 4 ppm Se in the diet was the highest dose level that produced no adverse effects and the study considered exposure through reproduction, this dose was considered to be a chronic NOAEL.

Final NOAEL: 0.4 mg/kg/d

Compound: Strontium (stable)
Form: Strontium Chloride (55% Sr)
Reference: Skoryna 1981
Test Species: Rat
Body weight: 0.35 kg (EPA 1988a)
Exposure Duration: 3 yrs (>1 yr = chronic).
Endpoint: Body weight and bone changes
Exposure Route: oral in water
Dosage: three dose levels:
70, 147, and 263 mg Sr kg/d;
NOAEL = 263 mg/kg/d
Calculations: not applicable

Comments: No adverse effects were observed for any Sr dosage level. Therefore, because the study considered exposure over three years, the maximum dose was considered to be a chronic NOAEL.

Final NOAEL: 263 mg/kg/d

Compound: 2,3,7,8 - Tetrachloro Dibenzodioxin (TCDD)
Form: not applicable
Reference: Murray et al. 1979
Test Species: Rat
Body weight: 0.35 kg (EPA 1988a)
Food Consumption: 0.028 kg/d (calculated using allometric equation from EPA 1988a)
Exposure Duration: 3 generations (>1 yr and during a critical lifestage = chronic).

Endpoint: reproduction
Exposure Route: oral in diet
Dosage: three dose levels:
0.001, 0.01, and 0.01 ug/kg BW/d; NOAEL = 0.001 ug/kg/d
Calculations: 0.001 ug/kg/d = 0.000001 mg/kg/d

Comments: Fertility and neonatal survival was significantly reduced among rats receiving 0.1 and 0.01 ug/kg/d. Because no significant differences were observed at the 0.001 ug/kg/d dose level and the study considered exposure throughout 3 generations including critical lifestages (reproduction), this dose was considered to be a chronic NOAEL.

Final NOAEL: 0.000001 mg/kg/d

Compound: 2,3,7,8 - Tetrachloro Dibenzodioxin (TCDD)
Form: not applicable
Reference: Nosek et al. 1992
Test Species: Ring-necked Pheasant
Body weight: 1 kg (EPA 1993e)
Exposure Duration: 10 weeks (10 week and during a critical lifestage = chronic).
Endpoint: reproduction
Exposure Route: weekly intraperitoneal injection
Dosage: three dose levels:
0.01, 0.1, and 1 ug/kg BW/week; NOAEL = 0.1 ug/kg/week
Calculations: 0.1 ug/kg/week = 0.0001 mg/kg/week = 0.000014 mg/kg/d

Comments: Egg production and hatchability was significantly reduced among birds receiving 1 ug/kg/week dose. No significant effects were observed among the other two dose levels. The weekly intraperitoneal injection exposure route used in this study is believed to be comparable to oral routes of exposure (EPA 1993e). Because no significant differences were observed at the two lower dose levels and the study considered exposure throughout a critical lifestage (reproduction), the 0.1 ug/kg/week dose was considered to be a chronic NOAEL.

Final NOAEL: 0.000014 mg/kg/d

Compound: 2,3,7,8 - Tetrachloro Dibenzofuran (TDBF)
Form: not applicable
Reference: McKinney et al. 1976
Test Species: 1-day old chicks
Body weight: 0.121 kg (mean$_{♂+♀}$ at 14 d; EPA 1988a)
Food Consumption: 0.0126 kg/d (calculated using allometric equation from EPA 1988a)
Exposure Duration: 21 d
(<10 weeks and not during a critical lifestage = subchronic).
Endpoint: mortality, weight gain

Exposure Route: oral in diet
Dosage: two dose levels:
1 and 5 ppb; LOAEL = 1 ppb
Calculations:

$$\left[\frac{0.001 mg\ TDBF}{kg\ food} \ x\ \frac{12.6 g\ food}{day} \ x\ \frac{1 kg}{1000 g}\right] \ /\ 0.121\ kg\ BW = 0.0001\ mg/kg/d$$

Comments: Because chicks exposed to 1 and 5 ppb TDBF experienced 16% and 100% mortality, respectively, the 1 ppb dose was considered to be a subchronic LOAEL. A chronic NOAEL was estimated by multiplying the subchronic LOAEL by a subchronic-chronic uncertainty factor of 0.1 and a LOAEL-NOAEL uncertainty factor of 0.1. To estimate daily TDBF intake throughout the 21d study period, food consumption of 2-week-old chicks was calculated. While this value will over- and underestimate food consumption by younger and older chicks, it was assumed to approximate food consumption throughout the entire 21 day study.

Final NOAEL: 0.000001 mg/kg/d

Compound: 1,1,2,2-Tetrachloroethylene
Form: not applicable
Reference: Buben and O'Flaherty 1985
Test Species: Mouse
Body weight: 0.03 kg (EPA 1988a)
Exposure Duration: 6 weeks
(< 1 yr and not during a critical lifestage = subchronic).
Endpoint: Hepatotoxicity
Exposure Route: oral gavage
Dosage: seven dose levels (administered daily 5 days/week for 6 weeks):
20, 100, 200, 500, 1000, 1500, and 2000 mg/kg/d;
NOAEL = 20 mg/kg/d
Calculations: not applicable

Comments: Because mice were exposed for 5 days/week, 7 day/week exposure were estimated by multiplying doses by 0.7 (5 days/7 days). Hepatotoxicity was observed at doses of 100 mg/kg/d or greater. Therefore, the 20 mg/kg/d dose was considered to be a subchronic NOAEL. A chronic NOAEL was estimated by multiplying the subchronic NOAEL by a subchronic-chronic uncertainty factor of 0.1

Final NOAEL: 1.4 mg/kg/d

Compound: Thallium
Form: Thallium Sulfate
Reference: Formigli et al. 1986

Test Species: Rat
Body weight: 0.365 kg (from study)
Exposure Duration: 60 days
(< 1 yr and not during a critical lifestage = subchronic).
Endpoint: reproduction (male testicular function)
Exposure Route: oral in water
Dosage: one dose level: 10 ppm Tl = LOAEL
Calculations: mean daily intake (from study) = 270 ug Tl/rat
= 0.74 mg/kg/d

Comments: Because rats exposed to 10 ppm Tl in the diet displayed reduced sperm motility and the study considered exposures only for 60 d , this dose was considered to be a subchronic LOAEL. A chronic NOAEL was estimated by multiplying the subchronic LOAEL by a subchronic-chronic uncertainty factor of 0.1 and a LOAEL-NOAEL uncertainty factor of 0.1.

Final NOAEL: 0.0074 mg/kg/d

Compound: Toluene
Form: not applicable
Reference: Nawrot and Staples 1979
Test Species: Mouse
Body weight: 0.03 kg (EPA 1988a)
Exposure Duration: days 6-12 of gestation
(during a critical lifestage = chronic).
Endpoint: reproduction
Exposure Route: oral gavage
Dosage: three dose levels:
0.3, 0.5, and 1 mL/kg/d; LOAEL = 0.3 mL/kg/d
Calculations: density of toluene =0.866 g/mL (Merck 1976)

$$\left[\frac{0.3 mL\ Toluene}{kg\ BW}\ x\ \frac{0.866 g\ Toluene}{mL\ Toluene}\ x\ \frac{1000 mg}{1 g}\right] = 259.8\ mg/kg/d$$

Comments: Toluene exposure of 0.5 and 1.0 mL/kg/d significantly reduced fetal weights. Embryomortality was significantly reduced by all three dose levels. While the toluene exposures evaluated in this study were of a short duration, they occurred during a critical lifestage. Therefore, the 0.3 mL/kg/d dose was considered to be a chronic LOAEL. A chronic NOAEL was estimated by multiplying the chronic LOAEL by a LOAEL-NOAEL uncertainty factor of 0.1.

Final NOAEL: 25.98 mg/kg/d

Compound: Toxaphene
Form: not applicable

Reference: Kennedy et al. 1973
Test Species: Rat
Body weight: 0.35 kg (EPA 1988a)
Food Consumption: 0.028 kg/d (calculated using allometric equation from EPA 1988a)
Exposure Duration: 3 generations (>1 yr and during a critical lifestage = chronic).
Endpoint: reproduction
Exposure Route: oral in diet
Dosage: two dose levels:
25 and 100 ppm; NOAEL = 100 ppm
Calculations:

$$\left(\frac{100 mg\ Toxaphene}{kg\ food} x \frac{28 g\ food}{day} x \frac{1 kg}{1000 g} \right) / \ 0.35\ kg\ BW = 8\ mg/kg/d$$

Comments: No adverse effects were observed at either dose level. Therefore because the study considered exposure over 2 generations and included reproduction, the 100 ppm dose was considered to be a chronic NOAEL.
Final NOAEL: 8 mg/kg/d

Compound: 1,1,1-Trichloroethane
Form: not applicable
Reference: Lane et al. 1982
Test Species: Mouse
Body weight: 0.035 kg (from study)
Water Consumption: 6 mL/d (from study)
Exposure Duration: 2 generations (>1 yr and during a critical lifestage = chronic).
Endpoint: reproduction
Exposure Route: oral in water
Dosage: three dose levels:
100, 300, and 1000 mg/kg/d
No effects observed at any dose level.
Calculations: not applicable
Comments: Because no significant differences were observed at any dose level and the study considered exposure throughout 2 generations including critical lifestages (reproduction), the maximum dose was considered to be a chronic NOAEL.
Final NOAEL: 1000 mg/kg/d.

Compound: Trichloroethylene
Form: not applicable
Reference: Buben and O'Flaherty 1985
Test Species: Mouse

Body weight: 0.03 kg (EPA 1988a)

Exposure Duration: 6 weeks
(<1 yr and not during a critical lifestage = subchronic).

Endpoint: Hepatotoxicity

Exposure Route: oral gavage

Dosage: seven dose levels (administered daily 5 days/week for 6 weeks): 100, 200, 400, 800, 1600, 2400, and 3200 mg/kg/d; LOAEL = 100 mg/kg/d

Calculations: not applicable

Comments: Because mice were exposed for 5 days/week, 7 day/week exposures were estimated by multiplying doses by 0.7 (5 days/7 days). Hepatotoxicity was observed at doses of 100 mg/kg/d or greater. Therefore, the 100 mg/kg/d dose was considered to be a subchronic LOAEL. A chronic NOAEL was estimated by multiplying the subchronic NOAEL by a subchronic-chronic uncertainty factor of 0.1 and a LOAEL-NOAEL uncertainty factor of 0.1.

Final NOAEL: 0.7 mg/kg/d

Compound: Uranium

Form: Uranyl acetate (61.32% U)

Reference: Paternain et al. 1989

Test Species: Mouse

Body weight (from study): 0.028 kg

Exposure Duration: 60 d prior to gestation, plus through gestation, delivery and lactation (during a critical lifestage = chronic).

Endpoint: reproduction

Exposure Route: oral intubation

Dosage: three dose levels:
5, 10, and 25 mg uranyl acetate /kg/d;NOAEL=5 mg/kg/d or

Calculations: NOAEL dosage of elemental U is:
0.6132 x 5 mg uranyl acetate /kg/d or 3.07 mg U/kg/d.

Comments: Significant differences in reproductive parameters (e.g., no.dead young/litter, size and weight of offspring, etc.) were observed at the 10 and 25 mg/kg/d dose levels. Because no significant differences were observed at the 5 mg/kg/d level and the study considered exposure throughout a critical lifestage (reproduction), this dose was considered to be a chronic NOAEL.

Final NOAEL: 3.07 mg U/kg/d.

Compound: Uranium

Form: depleted metallic

Reference: Haseltine and Sileo 1983

Test Species: Black Duck

Body weight: 1.25 kg (mean$_{♂+♀}$; Dunning 1984)

Food Consumption: Congeneric Mallard ducks, weighing 1 kg consume 100 g food/d (Heinz et al. 1989). Therefore, it was assumed that a 1.25 kg black duck would consume 125 g food/d.

Exposure Duration: 6 weeks
(<10 wks and not during a critical lifestage = subchronic).

Endpoint: mortality, body weight, blood chemistry, liver or kidney effects

Exposure Route: oral in diet

Dosage: four dose levels:
25, 100, 400, and 1600 ppm U in food;
NOAEL = 1600 ppm

Calculations:

$$\left[\frac{1600 mg\ U}{kg\ food}\ x\ \frac{125 g\ food}{day}\ x\ \frac{1 kg}{1000 g}\right]\ /\ 1.25\ kg\ BW\ =\ 160\ mg/kg/d$$

Comments: No effects observed at any dose level. Because this study was less than 10 weeks in duration and did not consider a critical lifestage (i.e., reproduction), it is considered to be subchronic. To estimate the chronic NOAEL, the subchronic NOAEL was multiplied by a subchronic-chronic uncertainty factor of 0.1.

Final NOAEL: 16 mg U/kg/d.

Compound: Vanadium

Form: Sodium Metavanadate ($NaVO_3$; 41.78% V)

Reference: Domingo et al. 1986

Test Species: Rat

Body weight (from study): 0.26 kg

Exposure Duration: 60 d prior to gestation, plus through gestation, delivery and lactation (during a critical lifestage = chronic).

Endpoint: reproduction

Exposure Route: oral intubation

Dosage: three dose levels:
5, 10, and 20 mg $NaVO_3$ /kg/d; LOAEL=5 mg/kg/d

Calculations: LOAEL dosage of elemental V is:
0.4178 x 5 mg $NaVO_3$ /kg/d or 2.1 mg V/kg/d.

Comments: Significant differences in reproductive parameters (e.g., no.dead young/litter, size and weight of offspring, etc.) were observed at all dose levels. Therefore, the lowest dose was considered to be a chronic LOAEL. To estimate the chronic NOAEL, the chronic LOAEL was multiplied by a LOAEL-NOAEL uncertainty factor of 0.1.

Final NOAEL: 0.21 mg V/kg/d.

Compound: Vanadium

Form: Vanadyl Sulfate

Reference: White and Dieter 1978
Test Species: Mallard Duck
Body weight: 1.17 kg (from study)
Food Consumption: 0.121 k/d (from study)
Exposure Duration: 12 weeks (>10 wks = chronic).
Endpoint: mortality, body weight, blood chemistry
Exposure Route: oral in diet
Dosage: three dose levels:
2.84, 10.36, and 110 ppm V in food;
NOAEL = 110 ppm
Calculations:

$$\left[\frac{110mg\ V}{kg\ food}\ x\ \frac{121g\ food}{day}\ x\ \frac{1kg}{1000g}\right]\ /\ 1.17\ kg\ BW\ =\ 11.38\ mg/kg/d$$

Comments: No effects observed at any dose level. Because this study was greater than 10 weeks in duration and did not consider a critical lifestage (i.e., reproduction), the maximum dose was considered to be a chronic NOAEL.
Final NOAEL: 11.38 mg V/kg/d.

Compound: Vinyl Chloride
Form: not applicable
Reference: Feron et al. 1981
Test Species: Rat
Body weight: 0.35 kg (EPA 1988a)
Exposure Duration: lifetime (~144 wks)
Endpoint: longevity, mortality
Exposure Route: oral in diet
Dosage: three dose levels:
1.7, 5.0, and 14.1 mg /kg/d; LOAEL= 1.7 mg/kg/d or
Calculations: not applicable
Comments: Significantly reduced survivorship was observed at all dose levels, therefore the 1.7 mg/kg/d dose level was considered to be a chronic LOAEL. To estimate the chronic NOAEL, the LOAEL was multiplied by a LOAEL-NOAEL uncertainty factor of 0.1.
Final NOAEL: 0.17 mg/kg/d.

Compound: Xylene (mixed isomers)
Form: not applicable
Reference: Marks et al. 1982
Test Species: Mouse
Body weight: 0.03 kg (EPA 1988a)

Exposure Duration: days 6-15 of gestation
(during a critical lifestage = chronic).
Endpoint: reproduction
Exposure Route: oral gavage
Dosage: six dose levels:
0.52, 1.03, 2.06, 2.58, 3.10, and 4.13 mg/kg/d;
NOAEL = 2.06 mg/kg/d
Calculations: not applicable

Comments: Xylene exposure of 2.58 mg/kg/d or greater significantly reduced fetal weights and increased the incidence of fetal malformities. While the xylene exposures evaluated in this study were of a short duration, they occurred during a critical lifestage. Therefore, the highest dose that produced no adverse effects, 2.06 mg/kg/d, was considered to be a chronic NOAEL.

Final NOAEL: 2.06 mg/kg/d

Compound: Zinc
Form: Zinc Oxide
Reference: Schlicker and Cox 1968
Test Species: Rat
Body weight: 0.35 kg (EPA 1988a)
Food Consumption: 0.028 kg/d (calculated using allometric equation from EPA 1988a)
Exposure Duration: days 1 -16 of gestation (during a critical lifestage = chronic).
Endpoint: reproduction
Exposure Route: oral in diet
Dosage: two dose levels:
2000, and 4000 ppm Zn; NOAEL = 2000 ppm
Calculations:

$$\left[\frac{2000\,mg\ Zn}{kg\ food} \ x\ \frac{28\,g\ food}{day} \ x\ \frac{1\,kg}{1000\,g}\right] /\ 0.35\ kg\ BW = 160\ mg/kg/d$$

Comments: Rats exposed to 4000 ppm Zn in the diet displayed increased rates of fetal resorption and reduced fetal growth rates. Because no effects were observed at the 2000 ppm Zn dose rate and the exposure occurred during gestation (a critical lifestage), this dose was considered a chronic NOAEL.

Final NOAEL: 160 mg/kg/d

Compound: Zinc
Form: Zinc Carbonate
Reference: Gasaway and Buss 1972

Test Species: Mallard Duck
Body Weight: 1 kg (from Heinz et al. 1989)
Food Consumption: 100 g/d (from Heinz et al. 1989)
Exposure Duration: 60 days (<10 wks and not during critical lifestage=subchronic)
Endpoint: Mortality, body weight, and blood chemistry
Exposure Route: oral in diet
Dosage: four dose levels:
3000, 6000, 9000, and 12000 ppm Zn; 3000 ppm = LOAEL
Calculations:

$$\left[\frac{3000 mg\ Zn}{kg\ food} \ x\ \frac{100 g\ food}{day} \ x\ \frac{1 kg}{1000 mg}\right] / 1\ kg\ BW = 300\ mg/kg/d$$

Comments: Because high mortality was observed at all does levels and the study was less than 10 weeks in duration, the lowest dose (3000 ppm Zn) was considered a subchronic LOAEL. A chronic NOAEL was estimated by multiplying the subchronic LOAEL by a subchronic-chronic uncertainty factor of 0.1 and a LOAEL-NOAEL uncertainty factor of 0.1.
Final NOAEL: 3 mg/kg/d

Compound: Zirconium
Form: Zirconium Sulfate
Reference: Schroeder et al. 1968b
Test Species: Mouse
Body weight: 0.03 kg (EPA 1988a)
Water Consumption: 0.0075 L/d
Food Consumption: 0.0055 kg/d
(calculated using allometric equation from EPA 1988a)
Exposure Duration: lifetime (>1 yr = chronic).
Endpoint: lifespan, longevity
Exposure Route: oral in water (+incidental in food)
Dosage: one dose level:
5 ppm Zr (in water) + 2.66 ppm Zr (in food) = LOAEL
Calculations:

$$\left[\frac{5 mg\ Zr}{L\ water} \ x\ \frac{7.5 mL\ water}{day} \ x\ \frac{1 L}{1000 mL}\right] / 0.03\ kg\ BW = 1.25\ mg/kg/d$$

$$\left[\frac{2.66 mg\ Zr}{kg\ food} \ x\ \frac{5.5 g\ food}{day} \ x\ \frac{1 kg}{1000 g}\right] / 0.03\ kg\ BW = 0.488\ mg/kg/d$$

Total Exposure = 1.25 mg/kg/d + 0.488 mg/kg/d = 1.738 mg/kg/d

Comments: Because no significant treatment effects were observed at the 5 ppm dose level and the study considered exposure throughout the entire lifespan, this dose was considered to be a chronic NOAEL.

Final NOAEL: 1.738 mg/kg/d

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APPENDIX B

Body Weights, Food and Water Consumptions for Selected Avian and Mammalian Wildlife Endpoint Species

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Appendix B. Body Weights, Food and Water Consumption Rates, for Selected Avian and Mammalian Wildlife Endpoint Species

Species	Body Weight		Food Intake		Water Intake[a]	
	kg	Citation	kg/d	Citation	L/d	Citation
Mammals						
Short-tailed Shrew (*Blarina brevicauda*)	0.015	Schlesinger and Potter 1974	0.009	Barrett and Stueck 1976 Buckner 1964	0.0033	Chew 1951
Little Brown Bat (*Myotis lucifugus*)	0.0075	Gould 1955	0.0025	Anthony and Kunz 1977	0.0012	
Meadow Vole (*Microtus pennsylvanicus*)	0.044	Reich 1981	0.005	Estimated from Figure 2. in Dark et al. 1983.	0.006	
White-footed Mouse (*Peromyscus leucopus*)	0.022	Green and Miller 1987	0.0034	Green and Miller 1987	0.0066	Oswald et al. 1993
Eastern Cottontail (*Sylvilagus floridanus*)	1.2	Chapman et al. 1980	0.237	Dalke and Sime 1941	0.116	
Mink (*Mustela vison*)	1.0	EPA 1993e	0.137	Bleavins and Aulerich 1981.	0.099	
Red Fox (*Vulpes fulva*)	4.5	Storm et al. 1976[b]	0.45	Sargent 1978[c] Vogtsberger and Barrett 1973	0.38	
White-tailed Deer (*Odocoileus virginianus*)	56.5	Smith 1991	1.74	Mautz et al. 1976	3.7	
Birds						
American Robin (*Turdus migratorius*)	0.077	Dunning 1984	0.093	Skorupa and Hothem 1985 Hazelton et al. 1984	0.0106	
American Woodcock (*Scolopax minor*)	0.198	Dunning 1984	0.15	Sheldon 1975	0.02	

Appendix B. Body Weights, Food and Water Consumption Rates, for Selected Avian and Mammalian Wildlife Endpoint Species

Species	Body Weight		Food Intake		Water Intake[a]	
	kg	Citation	kg/d	Citation	L/d	Citation
Wild Turkey (*Meleagris gallipavo*)	5.8	Dunning 1984	0.174	Korschgen 1967	0.19	
Belted Kingfisher (*Ceryle alcyon*)	0.148	Dunning 1984	0.075	Alexander 1977	0.016	
Great Blue Heron (*Ardea herodias*)	2.39	Dunning 1984	0.42	Kushlan 1978	0.1058	
Barred Owl (*Strix varia*)	0.717	Dunning 1984	0.0468	Estimated according to Nagy (1987)	0.047	
Barn Owl (*Tyto alba*)	0.466	Johnsgard 1988	0.0625	Johnsgard 1988	0.035	
Cooper's Hawk (*Accipiter cooperi*)	0.439	Dunning 1984	0.034	Estimated according to Nagy (1987)	0.034	
Red-tailed Hawk (*Buteo jamaciencis*)	1.126	Dunning 1984	0.91	Wakely 1978	0.064	

[a] All values calculated according to Calder and Braun (1983) unless otherwise stated.
[b] Mean for males and females from both Iowa and Illinois.
[c] 0.069 g/g/d for nonbreeding adult times 4.5 kg BW

APPENDIX C

Selected Toxicity Data for Avian and Mammalian Wildlife

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Appendix C. Selected Toxicity Data for Avian and Mammalian Wildlife[a]

Chemical	Species	LOAEL		NOAEL	Acute or Lethal Dose/Conc.[b]	LD_{50} or LC_{50}
		Dose or Conc.[b]	Effect	Dose or Conc.[b]		
Aroclor 1016	ferret			20 ppm (9 mo)		
Aroclor 1016	mink	20 ppm (9 mo)	reproduction		20 ppm	
Aroclor 1221	bobwhite quail		30% mortality		6000 ppm (5 d)	
Aroclor 1221	Japanese quail					>6000 ppm (5 d)
Aroclor 1221	ring-necked pheasant				>4000 ppm (5 d)	
Aroclor 1232	bobwhite quail					3002 ppm (5 d)
Aroclor 1232	Japanese quail					>5000 ppm (5 d)
Aroclor 1232	ring-necked pheasant					3146 ppm (5 d)
Aroclor 1242	ferret	20 ppm (9 mo)	reproduction		20 ppm	
Aroclor 1242	mink	5 ppm (9 mo)	reproduction		10 ppm (9 mo)	
Aroclor 1242	Japanese quail	321.5 ppm (21 d)	reproduction			
Aroclor 1242	Japanese quail	10 ppm (45 d)	reproduction			
Aroclor 1248	screech owl		reproduction	3 ppm (18 mo)		
Aroclor 1248	chicken	10 ppm (8 wk)	reproduction	1 ppm (8 wk)		
Aroclor 1254	raccoon	50 mg/kg (8 d)	physiology			
Aroclor 1254	cottontail rabbit	10 ppm (12 wk)	weight loss			

Appendix C. Selected Toxicity Data for Avian and Mammalian Wildlife[a]						
		LOAEL		NOAEL	Acute or Lethal Dose/Conc.[b]	LD_{50} or LC_{50}
Chemical	Species	Dose or Conc.[b]	Effect	Dose or Conc.[b]		
Aroclor 1254	white-footed mouse	10 ppm (18 mo)	reproduction; decreased pup survival			
Aroclor 1254	quail	50 ppm (14 wk)	reproduction			
Aroclor 1254	Japanese quail	78.1 ppm (21 d)	reproduction			
Aroclor 1254	Japanese quail			20 ppm (8 wk)		
Aroclor 1254	Japanese quail	5 ppm (12 wk)	physiology			
Aroclor 1254	mourning dove	40 ppm (42 d)	metabolism			
Aroclor 1254	ring dove	10 ppm	reproduction			
Aroclor 1254	pheasant	12.5 mg (1x/wk, 17 wk)				
Aroclor 1260	bobwhite quail	5 ppm (4 mo)	thyroid weight			
Aroclor 1260	Japanese quail	62.5 ppm (21 d)	reproduction			
Arsanilic acid	rat					216 mg/kg
Cadmium	deer mouse	1 mg/L	infertility			
Cadmium	wood duck	100 ppm (3 mo)	pathology	10 ppm (3 mo)		
Cadmium	black duck	4 ppm (4 mo)	offspring behavior			
Cadmium chloride	mallard duck	20 ppm (30-90 d)	pathology			
Cadmium succinate	bobwhite quail					1728 ppm (5 d)

Appendix C. Selected Toxicity Data for Avian and Mammalian Wildlife[a]

Chemical	Species	LOAEL		NOAEL	Acute or Lethal Dose/Conc.[b]	LD_{50} or LC_{50}
		Dose or Conc.[b]	Effect	Dose or Conc.[b]		
Cadmium succinate	Japanese quail					2693 ppm (5 d)
Cadmium succinate	ring-necked pheasant					1411 ppm (5 d)
Cadmium succinate	mallard duck					>5000 ppm (5 d)
Chlordane	bobwhite quail					331 ppm (5 day)
Chlordane	Japanese quail					350 ppm (5 d)
Chlordane	Japanese quail	25 ppm (8 d)	reproduction			
Chlordane	ring-necked pheasant					430 ppm (5 d)
Chlordane	mallard duck					858 ppm (5 d)
Chlordane	golden eagle				100 mg/kg	10 mg/kg
Chromium (trivalent)	black duck (young)	10 ppm	survival			
Chromium - potassium dichromate	Japanese quail		5-d LC_{50}			4400 ppm
2,4,D	deer mouse			3 lb/acre		
DDD	cowbird	1500 ppm (17 d)	lethal			
DDE	cowbird	1500 ppm (27 d)	lethal			
DDE	Japanese quail	25 ppm (14 wk)	reproduction; liver	5 ppm (12 wk)		
DDE	rat-tailed bat			107 ppm (40 d)		

Appendix C. Selected Toxicity Data for Avian and Mammalian Wildlife[a]

Chemical	Species	LOAEL		NOAEL	Acute or Lethal Dose/Conc.[b]	LD_{50} or LC_{50}
		Dose or Conc.[b]	Effect	Dose or Conc.[b]		
p,p'-DDE	mallard duck	5 ppm (several mo)	thin egg shells	1 ppm		
p,p'-DDE	black duck	10 ppm (6 mo/yr)	thin egg shells			
p,p'-DDE	pigeon	18 mg/kg (8 wk)			36 mg/kg (8 wk)	
DDT	Japanese quail	25 ppm (14 wk)	reproduction			
DDT	Japanese quail	50 ppm (10 wk)	reproduction	5 ppm (10 wk)		
DDT	bobwhite quail	500 ppm (4 mo)	thyroid	50 ppm (4 mo)		
DDT	mallard duck	330 ppm (5 d)	growth			
DDT	mallard duck	50 ppm (6 mo)				
DDT	mallard duck					1869 ppm (5 d)
DDT	house sparrow				1500 ppm (3 d)	
DDT	white-throated sparrow	5 ppm (11 wk)	behavior; physiology			
DDT	earthworm	5 lb/acre	decreased population			
Di-butyl phthalate	mallard duck		5-d lethal concentration		>5000 ppm	
Di-butyl phthalate	ring dove	10 ppm	thin egg shells			

Appendix C. Selected Toxicity Data for Avian and Mammalian Wildlife[a]						
		LOAEL		NOAEL		
Chemical	Species	Dose or Conc.[b]	Effect	Dose or Conc.[b]	Acute or Lethal Dose/Conc.[b]	LD_{50} or LC_{50}
2,4-Dichlorophenyl-p-nitrophenyl ether	rat	100 ppm (97 wk)	reproduction	10 ppm (3 gen.)		2600 ppm
2,4-Dichlorophenyl-p-nitrophenyl ether	dog			2000 ppm (2 yr)		
Di(2-ethylhexyl)phthalate	ferret	10000 ppm (14 mo)	physiology			
Di(2-ethylhexyl)phthalate	ring dove			10 ppm		
Ferrous sulfate	rat					1187 mg/kg
Hexachlorobenzene	Japanese quail	20 ppm (90 d)	reproduction			
Hexachlorobenzene	Japanese quail				1 ppm (90 d)	
Hexachlorobenzene	mallard duck		30% mortality		5000 ppm	>5000 ppm
Hexachlorobutadiene	Japanese quail	0.3 ppm (90 d)				
Hexachlorophene	rat	100 ppm (3 gen.)	reproduction	20 ppm (3 gen.)		
Hexamethylphosphoric triamide	rat	2 mg/kg/d (169 d)	reproduction			
Kepone	Japanese quail				200 ppm (240 d)	
Lead	bobwhite quail			2000 ppm (6 wk)		
Lead acetate	Japanese quail	1 ppm (12 wk)	reproductiion			

Appendix C. Selected Toxicity Data for Avian and Mammalian Wildlife[a]						
		LOAEL		NOAEL		
Chemical	Species	Dose or Conc.[b]	Effect	Dose or Conc.[b]	Acute or Lethal Dose/Conc.[b]	LD_{50} or LC_{50}
Lead acetate	bobwhite quail	1000 ppm (6 wk)	growth			
Lead arsenate	rat					1545 mg/kg
Lead arsonate	Japanese quail					4185 ppm (5 d)
Lead arsonate	ring-necked pheasant					4989 ppm (5 d)
Lead, tetraethyl	mallard duck				6 mg/kg	
Lithium chloride	red-winged blackbird				15000 ppm (4 d)	
Magnesium	Japanese quail	1500 ppm (2 wk)	physiology	1000 ppm (2 wk)		
Mercuric chloride	Japanese quail			2 ppm (1 yr)		
Mercuric chloride	Japanese quail	4 ppm (12 wk)	physiology	2 ppm		
Mercuric chloride	chicken	100 ppm (8 wk)	reproduction			
Mercuric sulfate	chicken	100 ppm (8 wk)	reproduction			
Methyl mercury chloride	mallard duck			5 ppm (3 mo)		
Methyl mercury chloride	chicken	5 ppm (8 wk)	reproduction			
Methyl mercury dicyandiamide	mallard duck	0.5 ppm (1 yr)	reproduction			
Methyl mercury dicyandiamide	black duck	3 ppm (28 wk/yr, 2 yr)	reproduction			

Appendix C. Selected Toxicity Data for Avian and Mammalian Wildlife[a]						
		LOAEL		NOAEL	Acute or Lethal Dose/Conc.[b]	LD_{50} or LC_{50}
Chemical	Species	Dose or Conc.[b]	Effect	Dose or Conc.[b]		
Monosodium methanearsonate	white-footed mouse	1000 ppm (30 d)	physiology			300 mg/kg
Octochlorodibenzo-p-dioxin	rat	0.5 mg/kg (2 wk)	pathology	0.1 mg/kg (2 wk)		
PBB (hexabromo biphenyl)	Japanese quail	100 ppm (9 wk)	reproduction	20 ppm (9 wk)		
PBB (polybrominated biphenyl)	mink	1 ppm (10 mo)	reproduction			179 mg/kg 3.95 ppm
PBB	Japanese quail	25 ppm (7 d)	blood chemistry			
Sodium arsenite	mallard duck	100 mg/kg (1 d)	thin eggshells			
Sodium cyanide	coyote	4 mg/kg	physiology			
Sodium monofluoroacetate	mallard duck					3.71 mg/kg
Sodium monofluoroacetate	mallard duck				9.11 mg/kg	
Sodium monofluoroacetate	ring-necked pheasant				6.46 mg/kg	
Sodium monofluoroacetate	chukar partridge				3.51 mg/kg	
Sodium monofluoroacetate	quail				17.7 mg/kg	

Appendix C. Selected Toxicity Data for Avian and Mammalian Wildlife[a]						
		LOAEL		NOAEL	Acute or Lethal Dose/Conc.[b]	LD_{50} or LC_{50}
Chemical	Species	Dose or Conc.[b]	Effect	Dose or Conc.[b]		
Sodium monofluoroacetate	pigeon				4.24 mg/kg	
Sodium monofluoroacetate	house sparrow				3.00 mg/kg	
Sodium monofluoroacetate	kit fox					0.22 mg/kg
Sodium nitrate	Japanese quail				3300 ppm (7 d)	
Sodium nitrate	Japanese quail				660 ppm (15 wk)	
Thallium sulfate	golden eagle					120 mg/kg
Tribromoethanol	mallard duck				150 mg/kg	
Vanadyl sulfate	mallard duck	100 ppm (12 wk)	blood chemistry	10 ppm (12 wk)		
Zinc phosphide	kit fox					93 mg/kg
Zinc phosphide	red fox				10.64 mg/kg/d (3 d)	
Zinc phosphide	grey fox				8.6 mg/kg/d (3 d)	
Zinc phosphide	great horned owl				22.31 mg/kg/d (3 d)	

[a] Data extracted from TERRE-TOX database (Meyers and Schiller 1986). Complete citations for these data are not currently available.
[b] Dose in mg/kg/day; dietary concentration in ppm; water concentration in mg/L.

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